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CIVIL AND MECHANICAL ENGINEERING.

The Festiniog Railway.

From the London Civ. Eng. and Architects' Journal, September, 1866.

(Continued from page 323.)

Mr. G. P. Bidder, Past President, said he had listened to the paper with great interest. It was an evidence that the author, as a government official, had a view to the commercial results of railways. This system was not propounded as a measure of economy, in other respects than that there were cases in which the economy of constructing the narrow gauge should be considered, where it could be introduced, for the sake of the curves and gradients, in districts where the broader gauge could not be introduced. That was the only ground on which this question could be fairly considered; but the author did not pretend that a narrow gauge could be worked more cheaply than a broad gauge. The arguments adduced in favor of the economy of working the narrow gauge, if followed out, would lead to the conclusion that, if there were no gauge at all, a railway could be worked for nothing. The question was, not the cost of moving a carriage, but at what cost a ton of minerals, or coals, or a hundred passengers could be moved. As a matter of practice, a ton of minerals, or a hundred passengers, could not be moved on a narrow gauge more cheaply than on a broad gauge. That it was so in this case was shown in the figures given in the paper; for although the substitution of steam traction in place of horses was undoubtedly a proper thing to do, yet he did not understand the author as propounding the question of these narrow gauge railways to show that the cost of working, ton for ton, and passenger for passenger, was any cheaper than

working on a broader gauge. The author said distinctly, he did not propose this narrow gauge, except in isolated places, as in the instance given between Festiniog and Portmadoc, where the railway took the slates from the quarries to the ships, and had no connexion with any other railway. But a break of gauge, whether in India or elsewhere, was an avowed evil and could only be reconciled by the advantages of economy of construction, as compared with the cost and inconvenience of transshipment. As to these railways, he had no doubt for short branches or extensions, or even for village lines, it might be useful to introduce them. But in this country there were what were called the "Standing Orders of Parliament," which interfered very much with such lines. Engineers were allowed to deviate 5 feet vertically in open country, and were restricted to 2 feet in towns. Anything more absurd than that, it was impossible to conceive. In the neighborhood of London, where the country was flat, a limit of 5 feet might be suitable; but in districts where the inclination of the surface of the ground was 1 in 5, or 1 in 6, the 100 yards of lateral deviation might change the work from cutting to embankment; and the 5 feet might require to be 20 feet, or 30 feet. Parliament said, "A railway shall not cross a public highway in this country if it interferes with its level, excepting it be made with a gradient of 1 in 20 for a parish road, and 1 in 30 for a turnpike road; nor shall it cross a road on the level, without permission." Of course, these were questions of local circumstances: 1 in 20 might be a proper gradient for London; but there were districts where the normal gradients were 1 in 7 or 1 in 10, and where the traffic might amount to three vehicles, or four vehicles per day. No attention was, however, paid to that fact, nor were the reasons listened to, but a gradient of 1 in 20 was insisted on. He had had to say, on one occasion, in committee, that if such conditions were to be abided by he could not prove the preamble, for the gradient of the valley 1 in 11, 1 in 20 would go quite across the valley. But what he proposed was, to spend £500 in improving the road on the other side of the railway, leading to the nearest village, and then the bill was passed.

With regard to level crossings, he feared he had been a great offender, for on one line he had as many as thirty-eight level crossings on as many miles of railway. But now the rule was, that there should be no level crossings. In consequence of this, where the Great Eastern Railway crossed a country road at its apex, at a most convenient place for a station, especially for minerals, the engineer was compelled to avoid making a level crossing, though it was near the highest point of the country, and to raise that road 15 or 16 feet, at a cost he believed of £7000 or £8000. The company could not have a station there, the opening of the line was delayed for several months, and the thing was a nuisance to the neighborhood.

He offered these remarks, because this paper showed, that the author's mind was directed to commercial results. He said in effect "where the broad gauge is inappropriate have a narrow gauge." He agreed with him; but the question of commercial consideration entered as much into

broad as into the narrow gauge railways, and regard must be had to the local circumstances where each gauge might be applied.

Mr. E. Woods thought it was evident, from the observations which had been made, that no one system could be laid down, nor any one gauge be fixed upon, as applicable to all conditions of locality, traffic, &c., but that each district must be treated according to its circumstances. With regard to the Indian gauge of 5 feet 6 inches, he could quite understand, it was most desirable to construct branch lines on the same gauge as the main lines, and in a flat country like India the difference of cost as between a gauge of 5 feet 6 inches and a narrower gauge would not be great, the principal item being in the additional length of the cross-sleepers. The rails might be lighter than those of the main line, and the engines for working the branches made light in proportion. Six years ago he had to construct a railway in Chili, 27 miles in length. The line was situated in the lower range of the Andes, where the gradients were necessarily severe and the curves sharp. Here curves of 500 feet radius, in combination with gradients varying 1 in 20 to 1 in 30, constantly occurred. It was said, by the engineers of the country, that it would be impossible to work that line with locomotives, and accordingly it was laid out for mule traffic, and it was worked by mule power for eighteen months. But owing to the seasons, of drought, and other causes, the expenses of working were so high, that a decision was come to by the Directors to work the line by locomotive power. He was called upon to design the engines, and in his design he limited the weight on the driving-wheels to 7½ tons, but the difficulty was to get sufficient adhesion to take the loads up the severe inclines of 1 in 20 for 7 miles, and of 1 in 30 for 12 miles. That difficulty was overcome by putting 6 driving-wheels to the engines, and placing the front end on a bogie truck. The rails, of 42 lbs. to the yard, had stood exceedingly well, and up to this time were in good working order, for though the engines weighed 30 tons, the weight, being distributed over so many wheels, had produced no sensible injury to the rails. The ordinary working speed on the inclines was about 12 miles per hour.

From the experience of the working of that line, it was evident that railways of light and inexpensive construction might be advantageously worked, if due regard were paid to the adaptation of suitable rolling stock.

Mr. W. Bridges Adams said, in dealing with the question of light railways, there were two aspects from which to regard them, the commercial and mechanical. The latter might be a toy, but the former must have reference to utility. The object being to transport materials and men, there must be sufficient volume in the carriages to hold them conveniently. Now, it was not convenient to have the dimensions so reduced as to render it necessary to strap the passengers to the seats to prevent oversetting. It was quite true, that the narrower the gauge the shorter might be the distance between the axles, if rigidly parallel, so as to facilitate passing round sharp curves; but, on the other hand, the longer the vehicle the steadier would it run, and the rigid structures which formerly needed straight lines of way or very flat curves, might now cease

to be rigid, by provision being made for the axles to radiate on curves, and point truly to the centres of those curves. By this arrangement, and by the use of spring-tires, permitting the wheels to slip within the tires, it was now practicable for carriages or engines, with extreme wheels 25 feet apart, to roll without rail friction round curves of 2 chains radius, and this fact rendered the width of gauge, whether 2 feet or 7 feet, a matter of indifference as regarded curves. On the Norwegien line of 3 feet 6 inches gauge, engines of that class were now working.

In considering the cost of gauge, the saving could not be in the rails, but only in the length of the sleepers and the quantity of ballast, bridges, &c. The axles might be shorter, and material might be saved in length of cross-framings, but it did not follow that this was economical. With a given load, there was a certain space required to stow it, and there was a certain proportion of length to breadth of train which gave the best results in traction. A long narrow train was disadvantageous, and especially so on very sharp curves. The proportion of the width of rail gauge to the width of the carriages was another consideration. As a mechanical rule, the carriage bodies might be safely made double the width of the gauge. Beyond that width there would be a tendency to unsteadiness. A 2-feet gauge, by that rule, would only admit a carriage 4 feet wide, and that, even with passengers back to back, was very cramped. Again, with passengers so placed, 3 feet in length of the carriages would only carry four passengers; while seated fore and aft eight passengers could be carried in a 4-feet length of carriage, with a 3-feet gauge of rails, *i.e.*, one-fourth increase in length of train would double the number of passengers or volume of goods.

With a 2-feet gauge and wheels 2 feet in diameter, the boiler and framings should be carried above the wheels altogether. With a gauge of 3 feet 6 inches, the boiler might be between the wheels; and engine-wheels of only 2 feet in diameter seriously damaged the rails if heavily loaded. If of larger diameter, better adhesion might be attained. The worst gradient on the Festiniog line appeared to be 1 to 60, but with heavier gradients heavier engines would be needed, and there was now no difficulty in constructing engines with eight drivers to roll round curves of 2 chains on any gauge. The very important feature in the engine described was the great pressure of steam—200 lbs. to the inch.

There was no doubt that narrow gauges might be made at less cost than wide ones, but it was doubtful if any material saving could be made by reducing a 3-feet gauge to a 2-feet gauge, when it was considered, that the upper structures of the train must be provided with sufficient space for convenience.

There was one reason why it was desirable to make branch lines of a narrower gauge than main lines when the traffic was light, viz: to prevent heavy engines and vehicles from running on and destroying them. But in the coal traffic it was desirable and possible to employ wagons of the greatest capacity and length, capable of running round the sharpest possible curves and up to the pit's mouth, and in this case it was better to have no break of gauge. On a gauge of 4 feet 8½ inches, it was quite

practicable to use 8-wheel wagons, 40 feet long, by 9 feet wide, with an internal capacity of 1500 cubic feet.

Mr. Gregory, V.P., said, he was prepared to recognise the propriety of the measures adopted on the Festiniog Railway, under circumstances which, he thought, were special and peculiar; but the Institution and the profession would be bold if they attempted, on the data now before them, to adopt, as had been suggested, the idea of a supplementary narrow gauge for all small branch lines. He believed that the advantage of such a gauge was limited to local conditions, such as those described in the paper. There was an old line having branches into several slate workings, and on account of the gauge already existing in those workings, and the character of the works and the curves of the Festiniog Railway itself, it would have been exceedingly difficult to adopt the ordinary gauge; therefore the managers had endeavored to make the most they could of an exceptionally narrow gauge, by converting the main line into a line for general goods and passengers. They also did well to introduce locomotive power on the line; but all who heard the paper must feel that this was done under difficulties. He must record his protest against the theory, that the cost of the working expenses of railways was in proportion to the cubes of their width of gauge. The quantity of goods, or the number of passengers to be carried, was an essential element in such a question, and he thought that it might with as much correctness be affirmed that Messrs. Pickford could carry on their business more cheaply in costermongers' carts than in their usual vans. This illustration would show that such a theory could not be practically supported. He was sure while Mr. England had got work out of an engine, under difficult circumstances, with an exceptionally narrow base, that gentleman would state that he could obtain greater power, and more economy for a large amount of work, if he had a wider base to work upon.

In considering the circumstances under which an exceptionally narrow gauge might be adopted, it became necessary to investigate its supposed advantages. Setting aside the idea of any saving in working, when there was anything beyond a very limited traffic, these advantages appeared to be classed principally under two heads, viz: first, a saving in cost of construction, and, secondly, the easier use of sharp curves.

What had been done on the Festiniog Railway to make the most of its capabilities did not point to much saving in first cost; indeed, it seemed, as had been remarked, that the saving would extend to little beyond sleepers and ballast. It was pointed out in the paper, that to make the most of the wagon and carriage room, the rolling stock overhung so far that a width of 4 feet 6 inches was required between the rail and any bridge piers, and a 7-feet space between any two lines of rail; the result would be the necessity for a minimum structure width for a single line of 11 feet, as compared with 12 feet 8 inches on the ordinary gauge, and for a double line a width of 20 feet, as compared with 23 feet 5 inches in the ordinary gauge of 4 feet 8½ inches. Such a difference would produce so small a saving in the cost of the works as not to compensate for the disadvantages of having a very narrow

wheel base, which would limit the power of the engine, and, in the event of the derangement of the permanent way, would cause such unsteadiness in running, that the speed common on ordinary railways would be dangerous.

With regard to curves, the friction arising from the different length of the arcs of the outer and inner rails was greater on a broad gauge than on a narrow gauge, and as rolling stock was at present generally constructed with rigidly parallel axles, the most obvious advantage of an exceptionally narrow gauge was the smaller radius of curves that might be adopted. But, he thought, modern improvements were going far to overcome the difficulties of sharp curves, and he recognised the great value of such inventions as Mr. Adams' radial axles, by the application of which to the ordinary engines and rolling stock of the country, trains might run round sharp curves on the ordinary gauge as freely as on a narrower one.

As these two supposed advantages seemed likely to disappear, he therefore concluded that, seeing the loss which took place by the uneconomical application of the power of the engine, the fact that the ordinary gauge admitted of rolling stock, which would bear a smaller proportion of dead weight to the weight carried, and, last but not least, the evils of a break of gauge, it might be concluded, that if there was to be an exceptionally narrow gauge in this country, it could only be advantageously applied to exceptional cases.

Mr. T. E. Harrison said, he entirely agreed that it would be absurd to say, because this narrow gauge had been successful in its application in a particular state of things, therefore it was applicable generally. The particular case where it was applied was one in which the main traffic of the line was in slates, and the trucks were taken to where the slate was quarried, and where no large wagon could go. The slate was unavoidably brought down inclined planes in narrow wagons, and, if the gauge of the main line had been broad, must have been reloaded into broad gauge wagons. At Portmadoc the slates would have to be again transferred from the wagons to the ships alongside the quays: this narrow gauge was therefore the best means of conveying them to the port of shipment. As to the mode adopted for the conveyance of passengers, no doubt it was ingenious, and people traveled on the line with a good deal of comfort; but the works were so narrow that, when the train was standing still in a cutting, a passenger could hardly make his way past the edges of the carriages. That was not a railway which could be taken as a sample of what was desirable. It was a clever adaptation of a state of things which previously existed, and which had been designed with a different object, and, as far as it went, it was exceedingly good; but to suppose that the principle upon which it was constructed was to be applied to an unlimited extent where railways of the ordinary gauge existed, was a total fallacy. It was possible that there were exceptional parts of the country where such a system might be adopted; but at the present moment such an instance did not occur to his mind. He knew there was an intention to employ the narrow gauge in other slate quar-

ries; but those were particular cases, and he thought, if the Institution gave its sanction in any shape or way to the extension of the system to general traffic, it would be leading the public in a wrong direction.

Mr. Alfred Giles remarked, that it was some years since the battle of the gauges was fought, and he had scarcely expected a fresh campaign to be opened in this Institution in favor of a 2-feet gauge. The 7-feet gauge was known to be too wide. Mr. Hemans had observed that the Irish gauge of 5 feet 3 inches was wider than was necessary, and Sir Charles Fox had said that, if he had had his own way in India, he should have preferred to have laid the branch lines on the national gauge of this country instead of on the gauge of 3 feet 6 inches. This proved that the old gauge was not far from the right thing. The advantages claimed for the narrow gauge were, first, great facility in traversing sharp curves; secondly, economy in construction; and thirdly, the use of lighter rolling stock. The first two points had already been disposed of. He remembered seeing in Paris, some years ago, a little railway with a gauge of 4 feet 8½ inches running in a circle, the radius of which, he believed, was only 25 métres. He had seen trains run round that line with great facility; and if that were so, where was the necessity of making a 2-feet gauge to save a little in the radius of the curve? It was stated that the least curve on the Festiniog line had a radius of 2 chains, or about 40 métres. As to first cost, it had been shown that the economy could result only in a little shortening of the sleepers, and a little saving of ballast. This could not be put down at more than £300 a mile. Then, as to the weight of the rolling stock, credit was claimed for the engine being only 7½ tons weight; there was no reason why an engine of similar weight (plus a little extra for the longer axles) could not be applied to the ordinary gauge. But it had been asserted, that the weight of the rolling stock was increased as the cube of the gauge. If that were the case, the weight of the Great Western broad-gauge engines should be 343 tons. Looking at all these circumstances, it was clear that the national gauge was nearly the best that could have been chosen. On an ordinary road, where there was no limit as to gauge, carriages had a width of about 4 feet 6 inches, and even the smallest cart was wider than 2 feet. He hoped, therefore, that engineers would not adopt the idea that the 2-feet gauge was an example to be copied, when they knew, as had been remarked, that a break of gauge was a great public inconvenience.

Mr. J. J. Allport, having had many years' practical experience in the working of railways, would offer but one observation upon this very narrow gauge. For reasons which he would state, he was of opinion that it would be most objectionable to attempt to introduce it into the country generally. With respect to the existing broad and narrow gauges, it was well known to all practical men, that the weight of a train on the narrow gauge was as great as on the broad gauge, or rather, that engines could be constructed to take as great weights on the narrow gauge as on the broad gauge; and if engines were made much heavier than at present, various difficulties, such as of wear and tear, would arise. But there was one difficulty greater than all: the principal part of the work

of a train was at the stations, in the loading, unloading, and moving of trucks and carriages from one part of a station to another, across turntables or traversers; and any one who had had experience at a station worked upon the mixed gauge, or solely upon one or other of the gauges, must have been struck with the great additional expense in working the broad-gauge plant at the station. It was not difficult for a couple of men to move a narrow gauge truck or carriage to any part of the station; but to shift a broad-gauge plant, horses must be employed. The capacity of the goods wagons and coal trucks upon the narrow gauge had been gradually increased from about the size of the Newcastle chaldron of 2 tons 12 cwt. up to 8 tons, 9 tons, and 10 tons, for the load; but he thought all narrow gauge managers had come to the conclusion, that from 8 tons to 9 tons for trucks was the maximum load that should be carried on the narrow gauge, with a due regard to economy and safety. If that weight for the load was exceeded, the wagon itself had to be made so much heavier, and then the friction was considerably increased, causing hot axles and other objectionable results, so that it was not uncommon to see these heavy wagons standing under their load, at various sidings and stations, waiting to be repaired. On the Midland Railway there were between 17,000 and 18,000 coal trucks at work; for a long time the capacity of these trucks was limited to 6 tons: now the capacity had been increased to 8 tons; but the company did not approve of greater capacity than that. He was of opinion, that, for all practical purposes, the gauge of 4 feet 8½ inches was the best, and superior to either the broad or the narrower gauge. But there was another important consideration: if a very narrow gauge were adopted, it could only be on branches connected with main lines. That would involve, in all cases, transshipment of passengers, goods, and coals at the junctions; and in itself would cause a greater annual expense than the interest upon the increased first cost of the line upon the uniform gauge of the parent lines, both in the purchase of land and the construction of rolling stock. That was a fatal objection to the introduction of any gauge, other than that of the line with which these branches were connected. He had no doubt that in a very few years the gauge of 4 feet 8½ inches, as being the best adapted to the commercial wants of this country, would be the only one in use.

Mr. Zerah Colburn said, this paper raised the question, how small could a locomotive be made to give practically useful work? In 1852 the contractor for a portion of the works on the Great Western Railway of Canada employed the steam excavator, which no doubt many present had seen in former days on the Eastern Counties' line. For that purpose he proposed to lay the temporary line on the 3 feet 3 inches gauge, and wagons were built to hold each 15 cwt. as a load. Mr. Colburn designed and built a small 4-wheel tank engine for working these wagons, and six other similar engines were afterwards built. The tank was placed under the boiler between the frames, and as the gauge was so narrow, the fire-box was placed behind the driving-wheels, and to correct the overhanging weight the tank was carried as far forward as possible. These engines weighed 6 tons only, with fuel and water, and could be

easily taken apart, for carriage over common roads, into three principal portions, of which the heaviest weighed hardly more than 2 tons. The cylinders were 9 inches in diameter, with a length of stroke of 16 inches; and the wheels, of 3 feet diameter, were placed 4 feet 6 inches apart from the centres. The engines worked well, although, of course, only at moderate speeds.

Mr. James Brunlees knew the Festiniog Railway well, and though he did not question the success of working locomotives on so narrow a gauge mechanically, he much doubted its success commercially. On the other hand, he believed that, beyond a certain limit, the wider the gauge the less would be the dividends; he looked upon that as an established fact. Some years ago he constructed a narrow gauge line from Portmadoc to Gorsedda, the length of which was 8 miles and the gauge 3 feet. The total rise in the 8 miles was 900 feet, and the cost per mile, including land, was £2000. The sharpest curve had a radius of 400 feet, and the down loads were worked entirely by gravitation. But passengers were not carried on the line; and although he had advised this line to be made on a narrow gauge, he was not prepared to recommend its further adoption, unless for exceptional purposes or for purposes similar to the one in question. The want of uniformity of gauge was a great drawback to traffic in many parts of this country, and hence any departure from the ordinary gauge would perpetuate and augment that drawback.

Mr. Galbraith said, there was one principal involved in the paper which had been lost sight of in the question of the gauges; that was, was there no room in this country, particularly in the agricultural districts, for cheaply constructed railways on the gauge of 4 feet 8½ inches? He thought there was. There were many cases where, by adopting sharp curves and a light permanent way, with light engines and level crossings at public roads, a railway might be laid down for £4000 or £5000 per mile, which would pay a fair dividend upon the outlay; and he hoped it would be impressed upon the members of the Board of Trade, that, in respect of branch lines, on which the traffic was light, they ought to relax the stringent requirements with respect to expensive permanent way and costly works to avoid level crossings. He had been engaged in laying out a line in Devonshire of the character he suggested. If heavy earthworks and bridges were to be encountered, it was impossible that the line could be constructed to pay a dividend at all. In parts of Devonshire there were small public roads, the traffic on which did not exceed two vehicles or three vehicles per day. To maintain, at a heavy cost, the principle of avoiding level crossings in such cases was, he thought, unwise. In many cases, railway companies erected cottages along the line for the plate-layers to be near their work; and there could be no objection to the wives of the men attending to the gates at such level crossings, in consideration of living rent free. He thought curves of 10 or 12 chains radius, and level crossings where the public traffic was light, might be fairly admitted on branch lines, which, when constructed at £4000 or £5000 a mile, might be made to pay a dividend. In such cases, a light rail of 40 lbs. or 50 lbs. to the yard might be laid

down, which would carry the ordinary carriages, if not the ordinary engines; but for short branches of 10 miles or 12 miles, one engine or two engines might be specially provided by the company to work the branch alone. Such a plan as that was far preferable to an exceptionally narrow gauge, causing a break between the branch and the main line, and the consequent transshipment of the traffic, and the supply of fresh plant in the shape of carriages and wagons to work the traffic when so transferred. This question having been now fairly raised, he thought it was a point which ought not to be lost sight of, and which was well worthy of consideration.

Mr. Peter Barlow said, that though he was not of opinion that the gauge of 2 feet was expedient, or that any gauge at all approaching it was correct, yet he considered that the same gauge could not be suited to every description of traffic. The gauge adapted to the costermonger's cart would not answer for Pickford's vans, and the gauge of ocean steamers would not suit the penny boats on the Thames. He thought the cost of constructing a line was very little influenced by the width of the gauge; but was rather influenced by the width of the carriages. It was desirable that a uniform gauge should prevail all over the country, and good reasons ought to be shown for deviating from the established gauge. At the same time, he hardly conceived it was a gauge suited to all circumstances, and cases might arise in which the local traffic might be better provided for by a narrower gauge. What led him to think so was the result given by the author, who had shown that an engine weighing only 7½ tons could take a load of 50 tons up a gradient of 1 in 60. On the metropolitan lines, engines of 40 tons were often employed for less loads; but the exigencies of a metropolitan traffic required frequent and light trains, with power to get rapidly into speed, and thus resembled the case of the penny boats on the Thames. He agreed with Mr. Gregory that there was little economy in the construction of these exceptional gauges, and he thought what was done upon the 2-feet gauge might possibly be done upon the gauge of 4 feet 8½ inches. Still, the fact of what had been performed by the locomotives on the Festiniog line was worthy of attention, and he thought the Institution was much indebted to the author for having brought the subject forward.

Sir Cusack Roney had seen the gauges of Canada and the United States, and had traveled upon continental lines in various parts of Europe. He had also had the opportunity of seeing the working of many branch lines, and he was thoroughly convinced of the desirability of a uniformity of gauge in all cases, between the branches and the main lines. He considered that the gauge adopted in this country was the correct and really practicable one. In most parts of Europe he had met with nothing but the narrow gauge: with one exception—where the line was worked by horse power.

Mr. Robert Mallet begged to offer one or two observations in explanation. He had not intended to say, that in choosing a gauge the choice depended upon the purely physical considerations he had brought forward, but, on the contrary, that the choice of gauge must depend upon

prudential conditions, and, amongst other things, primarily upon the question of traffic. To put an obvious example: If the whole traffic were to be of cubes of granite, or other stone, each of 20 tons weight, a railway of even more than 7 feet gauge might not be sufficient. Thus, at the harbor works at Holyhead, the contractor's gauge was 9 feet or 10 feet, being employed for the transport of blocks of 15 tons. But for certain conditions and amounts of traffic, a narrower gauge than 4 feet 8½ inches would not only be sufficient, but would be found the most economical and advantageous. What he had stated with reference to gauge was, that it was a general physical fact, that both the first cost of the works, and of the rolling stock of any similar railways, and also the working expenses for the haulage of any total of traffic, must increase with the width of gauge and as a high function of it, and that this function would probably be very nearly in the ratio of the cube of the gauges. English railways with a gauge of 7 feet, and those with a gauge of 4 feet 8½ inches, could not be compared in those respects, not being similar either in way or in rolling stock. Thus, as respected the wheels and axles, those of the Great Western were rather lighter, being obviously weaker than those used on the narrow gauge, and having only the same width of tread. In the case of the passenger carriages, as a whole, he found the bodies were nearly of the same breadth on the narrow gauge as on the broad; on the former the overhang was greater. It was thus impossible to establish any ratio whatever between the width of gauge and rolling stock, where there was no similarity of construction on the two different gauges.

With respect to the remark, that if the width of gauge were "nil" the cost of working would be also "nil," it should be remembered, that on such an assumption the traffic also became "nil" at the same moment; so that while the mathematical deduction might be true, it did not in the least touch the question of the relative economy of the narrow and the wide gauges.

Mr. George England said, he did not for a moment apprehend that the narrow gauge of the Festiniog Railway was regarded as having been brought forward as a pattern for universal adoption. That line had been made fifteen years, and it was not originally contemplated that it would be worked by locomotives. During the time that the traction was performed by horses, the owners were satisfied both with the mode of traffic and the dividend the line yielded; and it was only when another company wished to take a wider gauge into the district that the working of so narrow a gauge by locomotive power was determined upon. It was done solely in self-defence: and he was applied to to carry out the object of drawing a load of 25 tons up an incline of 1 in 60 at the rate of six miles per hour. The first engine that was started took a load of 50 tons up the line at the rate of 12 miles per hour. That was simply the statement that the author had brought before the Institution. The line was 14 miles long in the incline: the wagons were taken into the slate quarries, and the locomotive was only adopted in order to suit local circumstances.

The valuable paper on the Festiniog Railway, which appeared in our last number, was read by its author, Captain Tyler, R.E., before the Institution of Civil Engineers, and the foregoing discussion thereon will be read with interest.

On the Connexion of Plates of Iron and Steel in Ship-building.

By NATHANIEL BARNABY, Asst. Const. of H. M.'s Navy.

From the London Civ. Eng. and Architects' Journal, October, 1866.

Much yet remains to be done to make iron ship-building a perfect art, and there is, perhaps, no one step remaining to be taken in the path of improvement more important than that of substituting a simple and efficient means of joining plates by welding, should it ever be discovered, for the present system of riveting. The loss of strength caused by the present system is considerable in iron, but appears to be still more serious in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. As an illustration of this, one or two of the many experiments which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality may be given. A piece of steel 4 feet long and 12 inches broad, was cut from a half-inch plate, of which the proof strength was 33 tons per square inch. This piece was reduced to 5 inches in width at the middle, was supported at the ends by square plates riveted to it, and was carefully centered. The plate should have broken at 82½ tons, and through the narrow part. It actually broke at 95¼ tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus, while the material in the middle of the plate withstood a strain of 38 tons per square inch, it actually broke through the holes at 16·38 tons per square inch, or less than one-half the strain.

In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were 1¼ inches from the edge instead of 2½ inches. The plate broke in a similar manner at 73 tons, which is only 15 tons per square inch of the section of steel broken. The holes in both these cases had been punched, and, in order to ascertain whether these curious results were due to the injuries supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first, 2½ inches from the edge, but were drilled instead of being punched. The plate then broke through the narrow part at 106·75 tons, or 47·53 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or from the series of which they form part, further than this, that all which I propose to advance concerning the necessity of bestowing greater attention on the comparative strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that, for the present at least, we must be content to connect iron plates by rivets placed in holes punched or drilled out of the material, and, therefore,

by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and ship-builder to study to make this connexion with as little sacrifice of strength as possible. In every such connexion, the tensile strength of the plates across the outer line of holes, of the butt strap or straps across the inner line of holes, and the resistance of the rivets to shearing, should be all equal. Two plates may be connected, for example, by butt straps, so as to reduce the strength of the plate by one hole only. The strength of the several parts has, in this case, been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of a three-quarter Bowling rivet, including friction, and taken either singly or in conjunction with others, is 10 tons, and that of rivets of other diameters is in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that this reduction is about 25 per cent. when the holes are punched 3 or 4 diameters apart.

This description of butt strap is of no value in ship-building, because the stringer and tie-plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economize material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than one-eighth of the iron. The remaining strength of the iron would then probably be $\frac{7}{8} \times \frac{7}{8} = \frac{7}{9}$ths of the whole, so that the straps connecting them should also give seven-ninths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt strap has to be caulked, this proportion of strength cannot be retained, as the rivet holes must then be placed nearer together. I take, for example, the connexion by means of a butt strap of two plates $\frac{3}{4}$-inch thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out one-third of the iron, reduce the strength of the remaining iron about one-fourth, and have left only $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$. The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connexion is made by means of a single strap, the value of the rivets will be about 71 tons, and if by a double strap, 142 tons. No appreciable advantage could be obtained from a second row of rivets in this case, unless the spacing along the edge could be increased. If the rivets are no nearer together than is necessary for caulking, a second or third row would give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the inner row where the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will justify me in thus restating them. But there are certain other considerations equally important, which have altogether escaped the notice of ship-builders. Let us suppose that we have a stringer or tie-plate, the strength of which is, at the beams

and at the butts, $\frac{7}{9}$ of the full strength of the plates, and that we have no means of increasing the strength at these points. Have we any means by which we can, without altering the strength of these points, increase the tensile power of the plate? I think the answer would generally be, we have not. The strength of the tie will be measured by the strength at the weakest place, and this strength is fixed. What I want to show is, that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie-plate crossing a number of beams, say 3 feet 6 inches apart, at each of which the strength is reduced to seven-ninths of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points. But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount which it would stretch before breaking. It is, in fact, the work done in producing rupture, viz: the force applied, multipled by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the strong parts of the plate lying between the beams; it will all be thrown on the weak points, and if any one of these be weaker in any sensible degree than the rest, it will be confined to that point. This being the case a large increase of power may be obtained by reducing the strength of the plate between the weak points to the strength at these points, or even to less than this, provided we get long spaces of uniform strength to give elongation.

To illustrate this I will refer to some experiments made at Chatham with armor bolts, with reference to a proposal of Captain Palliser's. The proposal was to apply to armor bolts, having screws cut on them, the well-known principle that the bolts would be strengthened at the screw-thread, and become less liable to a break by a sudden jar, if the bolt, or a portion of it beyond the thread, were reduced in section to the same area as the iron left uncut at the thread.

The experiments referred to, made under my own careful observation, showed—

1. That iron bolts of good quality and of uniform diameter, subjected to a steadily increasing strain, elongate before breaking about one-fifth of their original length.

2. If the diameter is not uniform, but is decreased through a portion of the length, then the reduced part elongates about one-fifth of its length before breaking, and the larger portion scarcely stretches at all.

3. If this reduced part is very short, as in the thread of a screw, the strain required to break the bolt is the same per square inch of the unstretched or original section as in the previous cases; but there is scarcely any elongation before rupture.

4. If the whole length of the bolt is made to the reduced diameter

of the screw-thread, so that the thread projects from the bolt, the breaking strain (gradually applied) is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied.

The details of one portion of these experiments were as follows:

Four bolts were taken, all made of best selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz: $2\frac{1}{4}$ inches, screw threads were cut in the ends of these and nuts fitted. The other ends were formed with heads, leaving a length of 21 inches between the heads and the nuts. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the anvil for a length of $4\frac{1}{2}$ inches in the middle of their length, to a diameter of $1\frac{7}{8}$ inches, which was the same as that of the iron remaining within the screw-threads. The two other bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results:

		Breaking strain in tons.	Sq. in. in sec. broken.	Tons per sq. in of this sec.	Elongation.			Where broken.
					In 5 ins.	In 15 ins.	In 2 ins.	
Bolts not reduced.	No. 1	63	2·76	22·8	Nil.	$\frac{1}{4}$	$\frac{1}{4}$	At thread.
	No. 2	69	2·76	25·0	Nil.	$\frac{5}{16}$	$\frac{1}{2}$ bare.	Do.
Bolts reduced.	No. 1	64	1·67	38·33	$\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	In reduced part.
	No. 2	65·5	2·07	31·58	$\frac{7}{8}$	1	$1\frac{1}{8}$	Do.*

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration one of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture. As the material is disposed at present in iron decks, and stringer and tie-plates, the plates are perforated in the lines of the beams, not only by the holes required for the rivets to attach the plating to the beams, but by the deck-bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, amounts, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 feet 6 inches, and between them the plate has its full strength, except where a butt occurs.

The consequence of this is, that when the deck is put in tension, the stretching is confined to these weak places, and the amount of work

* At the shoulder where there was a slight defect.

which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beam. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across the lines of riveting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates; but instead of this I propose to omit the butt straps, and to arrange the plates so that in each of these spaces there shall be a continuous series of butts and plates, in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spaces of uniform strength between the beams.

The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the shearing value of the rivets, and allows about one-third of the distance between the beams to be admitted. The advantages of one system over the other are, I think, the following:

1. In the ordinary system one-fifth or one-sixth of the iron is punched away: by that proposed only one-ninth or one-tenth is punched out. There is from this cause a gain in direct tensile strength, to which must be added an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under *compression* is limited, not by the area of section, but by its resistance to buckling between the beams. According to the ordinary mode this is very small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 feet 6 inches, the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connexion with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched; whereas, if the fastening is in the beam-flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and riveting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butts of the plates and in the straps have to be drilled to prevent the injury done by punching.

5. The weight of material admitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action

of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, is, I think, very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial decks, stringers, or ties in a ship or vessel, as to make the tensile strength of the unperforated plates, intervening between adjacent butts, equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, *i. e.*, across the row of holes made for the purpose of attaching the plates to the beams, angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength not greater than that of the weakest place in the combination. In these intervals elongation will take place (to an extent depending on their length) before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given strain in producing rupture. Also, in increasing the resistance to rupture under sudden strains in single plates, by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plate.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute for such decks or partial decks stringers on the ends of the beams, tie-plates near their middle, and diagonal braces between them, as I think it clear that, from the round up of the beams, and other causes, a considerable portion of this material is unable to succor the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top. Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private ship-builders to introduce partial iron decks, so formed, into ships designed for commerce. These proposals do not form the subject of any patent.

Recent Improvements in the Application of Concrete to Fire-proof Construction. By Mr. J. Ingle.

Read at the British Association, Nottingham, 1866.

From the London Civ. Eng. and Architects' Journal, October, 1866.

Amongst the various methods of fire-proof construction as applied to the floors, ceilings, and roofs of buildings, which have been in use within the last twenty or thirty years, those in which concrete forms the fire-resisting medium have been most frequently adopted. The main reason for this preference, no doubt, is that the horizontal form in which it is generally disposed suits best the requirements of modern construction.

Brick arches, though used almost without exception to carry the floors of the large fire-proof mills and warehouses of the manufacturing districts, have disadvantages which almost preclude their use in buildings of a more general or domestic character. They require walls and girders of great strength to sustain their weight and to withstand the outward thrust which they exert, and the depth which they occupy on account of their rise, when added to the board and joist arrangement above and the ceiling underneath, is so great as to involve a considerable increase of height in the building to obtain the same clear space between the floors and ceilings of the rooms. Of the systems of fire-proofing in which concrete forms the chief element, that of Messrs. Fox and Barrett is the one which has been most extensively used.

It consists of a series of light rolled iron joists fixed 2 feet apart, upon the lower flanges of which are placed fillets of wood at intervals of an inch or an inch and a half. Upon these a mass of concrete is thrown, the depth of the same being regulated to some extent by that of the iron joists, the concrete being generally brought up flush with their upper flanges.

The whole is then paved, or covered with an ordinary wood floor upon light sleeper joists. The underside of the floor receives a second series of wood fillets nailed transversely to the first, and at intervals of 12 or 15 inches, and upon these the ceiling is then formed in the ordinary manner.

The concrete used in this construction, in common with all others in which ordinary lime forms an ingredient, is not, strictly speaking, a fire-proof body. The cementing material which occupies the interstices between the fragments of stone or gravel becomes, like ordinary mortar, in setting, a weak carbonate of lime, and like the stone, from which it was originally burnt, is reduced by calcination to a state of lime. This effect would undoubtedly be produced upon any lime concrete which formed part of the construction of a floor exposed to a severe conflagration.

The application of water to lime in the caustic state converts it, of course, to a hydrate; and while undergoing this change it assumes double its original bulk and falls to powder. The consequences, therefore, which might naturally be expected to ensue from the play of water from the fireman's hose upon concrete floors in a calcined state, would be the

overthrow or fracture of the outer walls by their expansion. Some of the numerous instances of the destruction by fire of buildings, which were supposed to be secure from that danger, are probably owing to this circumstance.

I have more especially alluded to this radical defect of ordinary concrete as a fire-proof medium, because, in the system which I am about to describe, a kind of concrete is employed which retains its cohesion and a considerable portion of its original strength, though water be thrown upon it while in a red-hot state.

This method is a local invention, and is known as "Dennett's fire-proof construction." I shall speak first of the composition of the concrete, and then proceed to describe the manner in which it is applied.

Gypsum, known chemically as sulphate of lime, and which is one of the most perfect non-conductors of heat, is the most important constituent of the concrete, and is used in lieu of the ordinary lime as its cementing material. This gypsum, however, unlike that manufactured into the plaster of Paris which is used for ornamental purposes, undergoes a thorough calcination. The latter is simply roasted in ovens, the finer lumps of gypsum being carefully selected for the purpose. The effect of this roasting is merely to drive off so much of the water which enters into its chemical composition as to allow the gypsum to be ground by millstones.

The rapidity of setting, which is peculiar to this kind of plaster, is owing to the fact of its having but little water to take up in order to resume a state of consolidation.

For the manufacture of the plaster used in Dennett's concrete the coarser qualities of gypsum are used, such as, in fact, except for this purpose, would be thrown aside as mere waste. These inferior qualities are largely impregnated with clay, with the beds of which it alternates, and this clay when burnt becomes the very kind of material which is afterwards added artificially in the mixing up of concrete.

For this purpose any hard material possessing a high degree of porosity is used, such as furnace crosses, oolitic stone, or broken brick. The latter, being in most cases readily procurable, is generally used. It is necessary that all dirt and dust should be carefully screened out, so as to prevent the choaking of the pores of the brick.

The sizes of the lumps are graduated so that the smaller ones shall fill up the interstices of the larger. By this means, and by considerable force used in consolidating the concrete, it is made to consist of a large proportion of the hard material, and its strength is much increased by the proper observance of these precautions.

Some considerable time is occupied by the concrete in setting, as a great amount of water is required to be taken up by the plaster on account of its thorough calcination.

When the setting process is complete a degree of hardness is attained, however, to which that of ordinary plaster of Paris will bear no comparison, and which is equal to that of the best cements.

The form in which the concrete is generally applied to the construc-

tion of floors is that of an arch, or series of arches, with small rise. These are formed upon temporary centres, which may be removed after an interval varying from two to six days, according to the state of the atmosphere and the size of the arches.

Spans of from 6 feet to 12 feet can be bridged over in this manner, the thickness of the arch varying from 3 inches to 5 inches in the crown, and from 5 inches to 10 inches in the haunches. Rolled or riveted iron girders form the intermediate supports of the arches, while the outer haunches rest upon projections or corbel courses in the brickwork. Floors of corridors and cottage rooms can be formed, however, without the aid of any joists or girders whatever. Of course, the arch-form presupposes a certain amount of support from the abutments, but from the transverse strength and thoroughly homogeneous character of the material very little if any lateral thrust is exerted on the outer walls.

If a wood floor is required, sleeper-plates and light joists and boards are laid in the ordinary way; but if there is no necessity for this kind of finish, or if it is desirable to make the upper surface fire-proof, the haunches of the arches may be filled up to a horizontal line and paved with stone, tiles, cement, or asphalte, as may be desired.

The cheapest and best kind of paving, however, is that which may be formed by the concrete itself. To do this the porous material is graduated in size until the surface can be finished with the trowel. This surface can be executed in various tints, and with different degrees of polish.

For bed-room floors this method of finish is particularly adapted; it is cleanly, non-absorbent, free from vibration, and therefore comparatively noiseless; and, what is a very important consideration, particularly in the crowded districts of large towns, affords no harbor for vermin. Any objection which might exist against these floors on the score of coldness may be removed by placing a sheet of hair, felt, or matting of cocoa fibre under the carpet.

Floors of coarse plaster laid upon reeds or laths on the ordinary joists were formerly very common, and are still used to some extent in Nottingham and other towns of the Midland district; and it is no doubt owing to this circumstance that the destruction of a dwelling-house by fire is here a matter of very rare occurrence indeed.

The mode of finishing the underside of these floors depends upon the character and architectural requirements of the building. For banks, offices, hospitals, and many other public buildings, there is often no objection to the curved surface which the soffits of the arches present, and which are, moreover, well adapted to receive colored decoration. Where, in buildings of a more domestic character, a flat ceiling is indispensable, a series of light joists to receive the ordinary lathing is affixed to the lower flanges of the girders. As these form no part of the main construction of the floor, their destruction in case of fire would not impair the stability of the arch, which forms the fire-proof medium.

With regard to the strength of the concrete, very severe tests were applied to some of these arches at the new town hall at Hackney, under

the direction of the district surveyor, and with very satisfactory results. These experiments were tried with reference to their capacity for sustaining dead pressure, and also with regard to their resistance to impact. In the latter case a rough block of stone weighing 250 lbs. was dropped from a height of 14 feet upon the centre of an arch which was but 3½ inches thick in the crown, and bruised but did not break it; while another block, weighing 750 lbs., let fall from a similar height upon an adjoining arch, went through with a clean fracture, causing no disturbance of the general construction.

Some further ideas of the strength and capabilities of the material may be formed when it is stated that vaults and domes have been executed therein at the new Foreign Offices, of spans varying from 10 feet to 36 feet. The vault of the latter dimension is semicircular on the section, and the concrete is 9 inches in thickness, with occasional ribs and groins to the side windows.

Mr. G. G. Scott, who first adopted this method of construction seven years ago for the thorough fire-proofing of Kelham Hall, near Newark, the seat of Manners Sutton, Esq., speaks of it in the following terms:

"I have made use of Messrs. Dennett's material for fire-proof arching, and though I have happily had no practical experience of its efficiency as against fire, I can bear witness to its strength and its extreme convenience of application. I have made use of it in positions in which I should have found it difficult to introduce any other fire-proof material, and it has this advantage, that the arches constructed of it are so entirely in one mass that they cover the space like a compact shell or inverted basin, and are, consequently, almost wholly free from lateral pressure."

The cost varies, of course, with the distance of the place where the system is adopted from the localities where the gypsum is quarried; but in most parts of the country it is found to be cheaper than any other method of fire-proofing, while in the immediate neighborhood cottage floors can be formed at a cost less than that of ordinary wood construction.

Cantor Lectures.—On Submarine Telegraphy. By Fleeming Jenkin, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 691.

LECTURE III.

(Continued from page 310.)

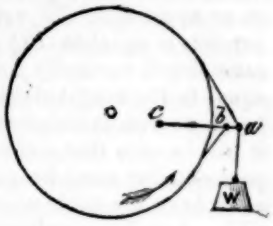
Laying and Repairing Cables.—The lecturer mentioned that he had received a letter from Messrs. Wells and Hall, stating that some lengths of their india rubber cables had been at work for some time under water. This was not doubted, but did not affect the original statement, that much india rubber had decayed, whereas no gutta-percha under water had decayed. Mr. Hooper had also misunderstood the statement in the abstract, that pure india rubber yielded to continued pressure. This was not meant to apply to Mr. Hooper's material, which is always more or

less vulcanized. Attention was also drawn to a map of the telegraph lines between Europe and the East, prepared by Messrs. Bright & Clark, and kindly lent by them. The following is an abstract of the lecture arranged under the heads of the syllabus:

1. *Stowage on Board Ship.*—The cable is coiled into large circular, or nearly circular, coils, so as to uncoil without receiving a twist, as shown on the last occasion. The coils are now held in iron water-tight tanks, and remain constantly under water. Tanks were first made for the Red Sea cable, but first used for the Malta-Alexandria cable. The tanks in the *Great Eastern* were three in number, from 51 feet 6 inches to 58 feet 6 inches diameter, and 20 feet 6 inches deep. To prevent rolling, their centre of gravity should be only slightly below the water-line. If the water be withdrawn from the tanks before the cable is paid out, the wires rust, and the chemical action heats them injuriously. With galvanized wires or cables covered with Bright & Clark's composition this heating does not occur. The eye of the coil round which the cable lies, generally from 6 to 8 feet in diameter, is filled with a cylinder, to prevent the bight of the cable from falling down, and possibly forming a kink or loop. Mr. Newall uses a cone permanently fixed in the centre of the coil. Messrs. Glass & Elliott lower their solid eye as the uncoiling proceeds. The cone appears to the lecturer to afford the best guarantee against kinking. It was used in the Persian Gulf expedition. When running out at high speeds, the cable, if unchecked, would fly out, urged by centrifugal force, so as to be dangerous and unmanageable. This tendency is controlled by rings, lowered as the tanks are emptied, and first forcing the cable to run horizontally towards the centre and then controlling its upward motion. These rings were first used by Messrs. Newall & Co.

2. *Break.*—From the tanks the cable is laid in troughs to the break, by which a restraining force is applied to prevent too rapid egress. The troughs in the *Great Eastern*, from the fore-hold to the break, measured 450 feet. The cable is wound four or five times round a drum 6 or 8 feet in diameter, and the rotation of this drum is controlled by friction. The turns round the drum hold the cable securely, and prevent its egress unless the drum itself turns. The riding of the cable is prevented by a simple contrivance known as a knife or plough, which was exhibited on a model. On the *Great Eastern* this knife or plough could be adjusted. The simplest manner of applying retarding friction to the break is to hang a weight on to a break strap, the other end of which is fixed. If the weight is hung from that end of the strap which would be lifted by the friction of the drum as it revolves, the retarding force can never exceed the weight, and a limit may be thus placed to the strain on the cable. But it was found in practice that, with a strap making less than one turn round the drum, a weight of say four tons had to be applied to give a friction of one ton. The limit due to the position of the weight was, in such a case, of small value, since any heating of the strap or dirt on its surface might rapidly increase the strain four-fold. Mr. Appold's break remedies this defect. The prin-

ciple on which it is constructed is illustrated by the annexed diagram. The end of the strap *a*, on which the greatest strain comes, is attached to a lever hinged at *c*. Between the centre of the drum and *a*, the other end is attached to the lever very near *a;* but between *a* and *c* the retarding friction is obviously equal to the difference of the strains on the end *a* and *b* of the break-strap, and the weight *w* is almost exactly equal to that difference. This relation does not depend on the co-efficient of friction between the strap and the drum. If the friction increases, the weight *w* is raised a little, and the lever *a c*, owing to the eccentrical position of *c*, slightly lengthens the break-strap, reducing the friction. The opposite effect occurs if the co-efficient of friction diminishes. The motion of *c a*, required to tighten or lossen the break-strap, is almost infinitely small, so that the angles of the break-strap and lever, and the relations of the strains, do not sensibly vary. This arrangement was used on the *Great Eastern*. It worked admirably, and gives a perfect safeguard against the application of any unforeseen strain by the friction of the break-strap. Strains may, however, occur from other causes, and for their detection a dynamometer is used between the break and the stern. The cable is passed under a weighted pulley, at a somewhat obtuse angle. The weight thus hanging on the cable is raised higher and higher as the strain on the cable increases. A scale is constructed by experiment showing the height corresponding to each strain. By this simple contrivance the actual strain on the cable can be observed at any moment. The following is a convenient formula for calculating the relation between the strains on break-straps and the friction produced. Let Q be the strain on that end of the strap which holds back the wheel, P the strain on the other end, f co-efficient of friction, and b the angle embraced by the strap in circular measurement, (unit = 57·296°.)



Then, $Q = e^{fb} P$, where $e = 2{\cdot}71828$.

f may be taken for	leather on iron, . .	= 0·35
"	" iron on iron, wet, . .	= 0·15
"	" wood on iron, wet, less than	0·1

3. *Theory of Submersion.*—In October, 1857, Professor William Thomson published in the *Engineer* a short sketch of the true mathematical theory of the form assumed by a cable while sinking, and the strains to which it is subjected under various conditions. The consequences of this theory were much more elaborately worked out (independently of Professor Thomson's publication, the lecturer believes) by Messrs. Brook & Longridge, in a paper read before the Institution of Civil Engineers, in the spring of 1858. Much of what follows is taken from that paper. If the ship and cable are both at rest in still water, the latter hangs in a catenary curve, the strains on which are known and easily computed. This case actually occurs whenever a ship stops paying out cable, for instance, to cut out a fault. If the cable were

suddenly stopped, so as to lie at a great angle with the vertical line, a strain would be produced so great as infallibly to break the cable. Thus, for a catenary in which the cable at the point of suspension lies at an angle of 9° 30′ with the horizon, the strain at the point of suspension is equal to 72½ times the weight of the cable hanging to the same depth vertically; so that in 2000 fathoms the strain would be equal to the weight of 145 miles of cable; but the Atlantic cable would break as soon as the strain exceeded the weight of 11 miles. From this it will be seen that a cable cannot be immediately stopped whilst being paid out, but must be gradually checked while the ship is backed, so as to keep the cable where entering the water as nearly vertical as possible. Another conclusion which follows is, that the cable while being paid out cannot possibly be hanging in a catenary curve; since the Atlantic cable did lie at an angle of about 9° 30′, and the strain, instead of being 2030 cwt., was only about 12 cwt. The following consideration may help us to perceive how different the case of a body sinking regularly is from the case of a chain at rest. Suppose the ship to drop a number of spheres of the specific gravity of the cable into the water at regular intervals; each of these would, within about two feet of the surface, acquire a definite sensibly constant velocity $v = \sqrt{\frac{w}{q}}$ where w = the weight, and q the resistance to the body moving at one foot per second. These spheres, moving with constant velocity at constant intervals of time, would lie in a straight line from the surface to the bottom, and would be more or less inclined to the horizon as the speed of the ship was less or greater. If the spheres were joined by an infinitely thin string, to which the water offered no resistance, they would form a cable which could be laid without any tension whatever, and with an amount of slack or waste depending simply on the inclination of the line to the horizon. The practical case of a submarine cable lies between these two extremes of the catenary and the isolated spheres; each short length of the cable lies like an inclined rod in the water, and has, therefore, a tendency to shoot back in a given direction, whereas the isolated spheres tend to fall vertically. Owing to this, cables, or at least heavy cables, cannot be laid without tension, except at the expense of an enormous waste of cable. It will be unnecessary here to repeat the whole mathematical investigation which is given in Messrs. Brook & Longridge's paper. It will be sufficient to give the results arrived at. Mathematical readers will readily understand that these results are calculable from the data given:

v = the velocity of the paying out vessel in feet per second.
v_1 = the velocity of the cable paid out in feet per second.
w = the weight of one foot length of the cable in pounds.
φ = the angle which the cable at the surface makes with a horizontal line.
x = the height of any point A from the bottom of the sea.
q = the resistance in pounds which the water opposes to the motion of each foot of the cable moving perpendicularly to itself,

speed of one foot per second; q may be called the co-efficient of resistance to displacement.

q_1 = the resistance in pounds which the water opposes to the motion of each foot of the cable drawn through it lengthwise at the speed of one foot per second; q_1 may be called the co-efficient of friction.

m = the resistance in pounds which the water opposes to the motion of each foot of the cable moving perpendicularly to itself, at the speed of v feet per second; m is assumed $= q\,v^2$.

m_1 = the resistance in pounds which the water opposes to the motion of each foot of the cable drawn through it lengthwise at the speed v; m_1 is assumed $= q_1\,v^2$.

t = tension in pounds at point A, which in what follows will be assumed as at the surface where the maximum strain occurs.

Then, if the cable be laid without any tension at the bottom, which is now invariably done, the equation to the curve assumed by the cable will become the equation to a straight line inclined at an angle to the horizon such that

$$(1.)\ \text{Cos. } \varphi = \frac{\sqrt{w^2+4m^2}-w}{2m},$$

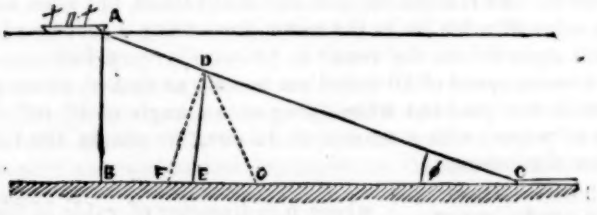
or, what amounts to the same,

$$(2.)\ \frac{\text{cos. } \varphi}{\text{sin.}^2\,\varphi} = \frac{q\,v^2}{w}.$$

From this it appears that the angle at which any given cable will be paid out is (when not tight at bottom) independent of the tension t, (or of the velocity v_1,) and is dependent simply on the velocity v of the ship. Cables which are bulky for their weight, or, in other words, are of light specific gravity, lie at a small angle; but, by increasing the ship's speed, any cable may be paid out at a small angle. We find further, when no slack is paid out,

$$(3.)\ t = \left(w - m^1\frac{(1-\text{cos. }\phi)^2}{\text{sin. }\phi}\right)x.$$

wx is simply the weight of the length of the cable hanging plumb from the ship to the bottom. This is the maximum tension that can be required to lay any cable without slack. This tension is always slightly



diminished by a certain small portion of its amount constant for a given speed and cable. The annexed diagram may help to explain the

results arrived at. The cable A C, lying on an inclined plane of water at the angle ϕ, is carried by a tension equal to the weight of a length A B of cable, somewhat as a chain would be in equilibrium lying on a frictionless inclined plane A C, and hanging down over a pulley at A to the depth B; but the inclined plane of water is not at rest. It yields under the cable at every instant at every spot; if the cable were pressed through the water in a direction perpendicular to itself, so that the plane of water yielded before the pressure of the cable, and did not slip along it at all, the above analogy would be perfect, and the tension at A would be simply equal to $w x$; but since we have supposed the cable to be laid without tension, and without slack at the bottom, any point D must finally come to a point E, such that E C = D C, and it will be easily seen that the point D to do this must move in a straight line E D. Now, this line D E is not perpendicular to A C; it falls within that perpendicular D F, so that if we suppose the plane of water under A C to yield perpendicularly before it, we must also conceive the cable as slipping back a little on the plane by an amount corresponding to the space between D F and D E; but this slip is opposed by the friction of the water, which thus tends to prevent the cable from running back on the inclined plane, and so relieves the tension by a small amount. This amount is so small that it may be practically neglected, and would not have been mentioned did not the same considerations enable us to understand the effect of laying cable with a certain amount of slack. When this is done, a point D moves in a line, say D G, differing much more in direction from D F than D E does. When much slack is laid, the cable slips back at a considerable velocity on the inclined plane, and meets with a frictional resistance tending considerably to relieve the tension. Thus, when the cable is paid out at a velocity v_1, we have

$$(4.)\quad t = \left[w - m^1 \frac{\left(\frac{v^1}{v} \cos.\ \phi\right)^2}{\sin.\ \phi} \right] x.$$

When v_1 is considerably in excess of v, the fraction of the whole tension which the friction m^1 subtracts from $w x$ is very considerable. It also increases rapidly as the speed of the ship increases, and it further increases if the specific gravity of the cable be small, for then it lies at great length in the water, presenting an immense surface to be gripped by the water. The friction on each foot is but small, but when twelve or thirteen miles of cable lie in the water, presenting a surface of 70,000 or 80,000 square feet, the result is practically very important. Assuming a mean speed of 10·4 feet per second as that at which the Atlantic cable was paid out when lying at an angle of 9° 30′ in 2000 fathoms of water, with a tension of 12 cwt., we obtain the following values for the constants:

$$\left.\begin{array}{l} q = 0{\cdot}085 = 0{\cdot}81\ \text{D} \\ q_1 = 0{\cdot}0085 = 0{\cdot}001\ \text{D} \end{array}\right\} \text{where D = diameter of cable in feet.}$$

From some observations, it would seem as if the angle had been even

less than the above, in which case q would be larger and q_1 smaller. From Beaufoy's experiments we should have expected q to be more nearly 0·65 D; but the roughness of the cable may account for the difference, as it certainly does for the great difference in the co-efficient of friction, which is nearly eight times that which a smooth surface would present. It is probable that, for a smooth iron cable, the value of q_1 would be more nearly equal to 0·001 D, and $q = 0·065$ D. One reason will now be plain for giving in the foregoing tables the strength of the various cables relatively to the depth in which they are to be laid. The strain required to lay them is always a fraction of that depth, but the strain will not be always the same fraction of the depth, but will be smaller for the lighter cables when laid slack.

4. *Application of Theory.*—The practical results of equation (4) are most important. To lay any cable, however light, quite taut, we require nearly the tension due to a weight of the cable hanging plumb from the surface to the bottom; but by increasing the bulk of any cable, though we do not diminish its actual weight, we may, by laying a little slack, diminish the tension very greatly. With such a cable as the second Atlantic the tension was thus diminished more than half; to lay it taut would have required nearly 28 cwt., and 12 cwt. was the amount actually required when about 15 per cent. slack was paid out. The strain could be maintained constant in all depths, by allowing a little more slack to run out in deep water, and even this could be prevented by a slight increase in the speed of the ship. No relief at all, comparable to the above, is obtained by paying out heavy cables slack; but, on the other hand, still lighter cables can be paid out under still more favorable conditions. The rattan and hemp cable (No. 11, Appendix 1) would, with 12 per cent. slack, be paid out without any strain at all, and if more slack than this were desired, the cable would have to be pushed out of the ship. Nearly the same might be said of a bare gutta-percha wire. The Atlantic cable, in the last expedition, was laid in depths varying from 1750 to 2000 fathoms, at speeds for the ship varying from $4\frac{3}{4}$ to $6\frac{3}{4}$ knots per hour, while the cable ran out at from 5 to nearly 8 knots per hour. The angle, according to one method of observation, varied from 9° to nearly 12°, but was somewhat less according to other observations; 9° 30′ seems to have been a usual angle. The slack paid out in deep water ranged from 9 per cent. to about $18\frac{1}{2}$ per cent. On the last day the slack was about 14·8 per cent. The strain on the cable was very constant, ranging from 10 cwt. to 14 cwt., and generally being between 11 cwt. and 13 cwt. The pitching of the ship never caused more than about 2 cwt. difference in the strain; but once, when going slow to change holds, the strain was 17 cwt.: this accords with theory. The lecturer has to thank the engineers of the Telegraph Construction and Maintenance Company for the above information.

(To be continued.)

Theory of the Influence of Friction upon the Mechanical Efficiency of Steam. By W. J. Macquorn Rankine, C.E., LL.D.

Paper read before the British Association, Nottingham, 1866.

From the London Civ. Eng. and Architect's Journal, October 1, 1866.

1. Attention has been called to the fact that the heat produced by the friction of the piston, piston-rods, and trunks of steam engines must be wholly or partly communicated to the steam, and must thus affect the work of the steam and the expenditure of the heat upon it. The object of the present paper is to point out how that fact, when treated according to the principles of thermodynamics, affected the efficiency of steam.

2. The most general and elementary way of considering the subject is as follows: Let W denote the whole indicated work of the steam in a given time, including that which is lost through friction in the cylinder; let F be the part of that work which is so lost, so that W—F is the available work; also let H be the whole expenditure of heat upon the steam in the same time, expressed in units of work by the aid of the first law of thermodynamics. Then $\frac{W}{H}$ is the efficiency of the steam when friction is not taken into account. If we take into account the loss of work through friction, but not the gain of heat, the efficiency is reduced to $\frac{W-F}{H}$. With respect to the gain of heat through friction, it is to be observed that, if the cylinder is properly jacketed and protected, the whole of the heat due to the friction of the piston must be communicated to the steam, and that, if we consider the great superiority of slightly moist steam above air in conducting power, it is probable that a small fraction only of the heat due to the friction of piston-rods and trunks escapes without being taken up by the steam also. If, then, we suppose that, sensibly, the whole due to friction in the cylinder is taken up by the steam, there is a corresponding saving in the expenditure of heat, and the efficiency of the steam becomes

$$\frac{W-F}{H-F}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A,)$$

being less than $\frac{W}{F}$, the efficiency neglecting friction; but greater than $\frac{W-F}{H}$, the efficiency when the loss of work is taken into account, but not the saving of heat.

3. For example, let the case be taken of an engine in which the steam is admitted to the cylinder at an absolute pressure of 40 lbs. on the square inch, being 25·3 lbs. on the square inch above the atmosphere, the back pressure being 4 lbs. on the square inch, and the rate of expansion 5 lbs.: the efficiency of the steam in such an engine, neglecting friction, is about $0{\cdot}12 = \frac{W}{H}$. Suppose, now, that one-tenth of the indi-

cated work is lost in friction in the cylinder, and that all the heat of friction is taken up by the steam; that is to say, let $\text{F} = 0{\cdot}1\ \text{W} = 0{\cdot}012\ \text{H}$: then the fraction 0·012 expresses the saving of heat through friction, and the efficiency is found by equation A to have the following value:

$$\frac{\text{W} - \text{F}}{\text{H} - \text{F}} = \frac{0{\cdot}12 - 0{\cdot}012}{1{\cdot}000 - 0{\cdot}012} = \frac{0{\cdot}108}{0{\cdot}988} = 0{\cdot}1093.$$

The result of taking into account the loss of work, but neglecting the saving of heat, is $\frac{\text{W} - \text{F}}{\text{H}} = 0{\cdot}108$.

4. The following is the result of applying the principles of thermodynamics more in detail to the process of expansive working as affected by friction. During any small portion of the process of expansive working, let $d\,\text{W}$ be the total work done, including friction, and $d\,\text{F}$ the part of that work which is lost in friction; also let t be the absolute temperature at which the work $d\,\text{W}$ is done, and k the real dynamical specific heat of the substance: then, by the second law of thermodynamics, the expenditure of heat during the given small portion of the process is $d\,\text{H} = t\,d\,\phi$; in which the "thermodynamic function" ϕ has the following value:

If all the heat due to the friction is taken up by the working substance, let $d\,\text{H}^1$ be the diminished expenditure of heat; then the thermodynamic equation of the process becomes

$$d\,\text{H}^1 = d\,\text{H} - d\,\text{F} = t\,d\,\phi - d\,\text{F}, \quad . \quad . \quad . \quad . \quad \text{(B.)}$$

And if, as is often sensibly the case, the work done in friction is a constant fraction of f of the whole work, so that $d\,\text{F} = f\,d\,\text{W}$, we have the following equation:

$$d\,\text{H}^1 = t\,d\,\phi - f\,d\,\text{W}, \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(C.)}$$

5. The special mode of operation of friction in saving heat during the working of steam in ordinary steam engines probably consists in a diminution of the additional supply of heat required by the steam while in the cylinder, in order to prevent the accumulation of liquid water there. It is known that during the expansive working of steam heat disappears: that part of such disappearance of heat (viz: from one-fourth to one-fifth of it) takes effect in lowering the temperature of the steam to that corresponding to the diminished pressure, and that the remainder (being from three-fourths to four-fifths) tends to produce liquefaction of part of the steam. Such liquefaction is known to cause, indirectly, great waste of heat, through the distillation of the liquid water into the condenser, and consequent abstraction from the cylinder of heat, which has to be supplied by means of an increased expenditure of boiler steam. In order to realize, therefore, the economy due to expansive working, it is necessary to keep the steam, during the expansion, nearly in a state of dryness; and for that purpose it must be supplied with heat to the extent of from three-fourths to four-fifths of the heat which disappears during the expansion. That supply of heat may be conveyed from the boiler either by means of a steam-jacket, or of superheating, or by both

methods combined; and the heat due to friction in the cylinder, by contributing to that supply, diminishes the part of it which it is necessary to obtain from the boiler.

6. The theoretical formulas for the indicated work, and the expenditure of heat in a steam engine working with dry saturated steam, are as follows:*

Let the initial absolute temperature, absolute pressure, and volume of one pound of steam be denoted, during the admission into the cylinder, by t_1, p_1, and v_1, and at the end of the expansion by t_2, p_2, and v_2; so that $\frac{v_2}{v_1}$ is the rate of expansion.

Let p_3 be the back pressure of the exhaust steam in the cylinder, and t_4 the absolute temperature of the feed-water.

Let $a - bt$ be the approximate value, in units of work, of the latent heat of evaporation of one pound of water at the absolute temperature t, the constants being as follows:

$a = 1109550$ foot-pounds;

$b = 540{\cdot}4$ foot-pounds per degree of Fahrenheit, or $972{\cdot}72$ foot-pounds per Centigrade degree.

Let J be Joule's equivalent of the specific heat of liquid water $= 772$ foot-pounds for Fahrenheit's scale, or 1390 foot-pounds for the Centigrade scale, nearly.

Let U denote the work done by a pound of steam, on the supposition that the back pressure is equal to the final pressure ($p_3 = p_2$), and W the whole indicated work done by a pound of steam.

Then
$$\text{U} = a \text{ hyp. log. } \frac{t_1}{t_2} - b\,(t_1 - t_2), \quad . \quad . \quad . \quad \text{(D,)}$$

and
$$\text{W} = \text{U} + (p_2 - p_3)\,v_2, \quad . \quad . \quad . \quad . \quad . \quad \text{(E;)}$$

also the expenditure of heat per pound of steam is
$$\text{H} = \text{U} + a - b\,t_2 + \text{J}\,(t_2 - t_4), \quad . \quad . \quad . \quad \text{(F.)}$$

Now the total heat of evaporation of one pound of steam, at the initial temperature t_1, is $\text{H}_1 = a - b\,t_1 + \text{J}\,(t_1 - t_4)$, ... (G,) and the difference between this and the total expenditure of heat is the additional heat which must be supplied to each pound of steam in order to prevent liquefaction in the cylinder, that is to say,

$$\text{H} - \text{H}_1 = \text{U}\,(\text{J} - b)\,(t_1 - t_2)$$
$$= a \text{ hyp. log. } \frac{t_1}{t_2} - \text{J}\,(t_1 - t_2), \quad . \quad . \quad . \quad \text{(H.)}$$

It appears, by calculating numerical results in particular cases, that
$$\text{H} - \text{H}_1 = \text{from } 0{\cdot}75 \text{ to } 0{\cdot}8\ \text{U, nearly}, \quad . \quad . \quad \text{(K,)}$$
$0{\cdot}75$ being the co-efficient at high temperature, and $0{\cdot}8$ at low.

7. It is out of this latter part of the expenditure of heat $\text{H} - \text{H}_1$ that the saving is made through the heat produced by the friction in the

* For their demonstration see "Phil. Trans.," 1859, and "A Manual of the Steam Engine and other Prime Movers," p. 396; and for approximate formulas for practical use, see also "The Engineer," Jan. 5, 1866, p. 1, and "Useful Rules and Tables," p. 282.

cylinder. The following are four examples of the theoretical calculation of the work and expenditure of heat per pound of steam, and of the efficiency, with and without allowances for friction:

No. of Example.	I.	II.	III.	IV.
Temperature—Fahrenheit.				
Initial, ordinary	338 deg.	338 deg.	257 deg.	257 deg.
" absolute, t_1 =	799 "	799 "	718 "	718 "
Final, ordinary	248 "	203 "	176 "	221 "
" absolute, t_2 =	709 "	664 "	637 "	612 "
Feed-water, ordinary	104 "	104 "	104 "	104 "
" absolute, t_4 =	565 "	565 "	565 "	565 "
Pressures—lb. on the square foot—				
Initial, p_1 =	16580	16580	4854	4854
Final, p_2 =	4152	1765	980	2524
Back, p_3 =	649	649	649	649
Volumes—cubic feet to the lb.—				
Initial, v_1 =	3·814	3·814	12·09	12·09
Final, v_2 =	14·00	31·26	53·92	22·34
Rates of expansion $\frac{v_2}{v_1}$ =	3·67	8·2	4·46	1·86
Indicated work in foot-pounds per pound of steam, at pressures above the final pressure, U =	83930	132350	89000	37600
Do. at pressures below the final pressure $(p_2 - p_3)\, v_2$ =	49042	34700	18140	41900
Total indicated work, foot-pounds, per lb. of steam, W =	132972	167050	107140	79500
Heat expended in foot-pounds per lb. of steam, before admission, H_1 =	859175	859175	740139	840139
Additional heat to prevent liquefaction (without deduction) $H - H_1$ =	62778	100623	69964	29139
Total heat expended (without deduction) H =	921953	959793	910103	860278
Efficiency without friction $\frac{W}{H}$ =	0·1442	0·174	0·1176	0·0915
Suppose co-efficient of friction one-tenth, then work lost in friction and heat saved F = $\frac{W}{10}$ =	13297	16705	10714	7950
Available work W − F =	119675	150345	96426	71559
Heat expended to prevent liquefaction, deducting that saved by friction, $H - H_1 - F$ =	49481	83918	59250	2118
Total heat expended, deducting that saved by fricton H − F =	908656	943093	899389	861328
Efficiency, allowing for friction $\frac{W - F}{H - F}$ =	0·132	0·1595	0·1073	0·083

8. From the preceding formulas and calculations it appears, that although the heat produced by friction in the cylinder makes but a trifling saving when compared with the whole heat expended, it may become considerable when compared with that part of the expenditure of heat which is employed to prevent liquefaction of steam in the cylinder, and may thus co-operate usefully with the action of jacketing and superheating.

In reply to some observations by Mr. Smith and Mr. Bramwell, the

latter of whom pointed out that the heat generated would be carried away in part by the exhaust, Professor Rankine said he was sorry that he should have explained himself so badly in his original paper as to lead Mr. Bramwell and Mr. Smith to suppose that he regarded the heat generated by friction as increasing the motive power. That was not what he had intended to convey. He was far from supposing that the heat generated by friction added in the slightest degree to the amount of the working power of the steam, or even made the diminution of the work less than it would otherwise be. What he meant to convey was that the effect which he had ascribed to the heat produced by friction was not a gain or saving of mechanical work, but simply a saving of a portion of the heat which would otherwise be lost in preventing liquefaction of the steam. Whatever quantity of heat was produced in the cylinder by friction, precisely to that extent would the heat which it was necessary to supply by means of jacketing or superheating be diminished. Steam must be dried or superheated by wire-drawing, or passing through a small aperture without performing work. Most engineers, however, would agree with him that to dry or superheat steam by that method was not economical, and that the same object could be better attained by the direct application of heat.

The Water-jet Propeller.

From the London Engineering, No. 43.

The data of the recent experimental trip of the *Water-witch*, although not complete, are sufficiently so to show a great waste of power in Mr. Ruthven's system of jet propulsion. It is, indeed, probable, and nearly demonstrable, that of the 750 horse power indicated on Friday less than one-fourth was actually utilized in propelling the ship. The action of the jets admits of very close investigation when the size of the orifices, the velocity of outflow, and what may be termed the velocity of reaction are given. In the case of the *Water-witch*, she is reported to have two jets, each of which, although not circular in form, is equal in area to a circle 2 feet in diameter, the area of both nozzles being 6·28 square feet. If we, for the moment, disregard friction and all deductions whatsoever for losses of any kind, we can easily find what quantity and velocity of sea-water would be maintained through these jets with 750 horse power. Taking sea-water to weigh 64 lbs. per cubic foot, we shall have 15,260 feet, nearly, per minute, discharged with a velocity of about 40½ feet per second, this velocity corresponding to a height of 25½ feet. For to impart to water a motion in any direction, horizontal or vertical, of 40½ feet per second is equal to lifting it to a height of 25½ feet, and to lift 15,260 cubic feet of sea-water per minute to a height of 25½ feet, requires, irrespective of all losses, about 750 indicated horse power. The size of the nozzles being fixed, there is but one quantity of water, and, therefore, but one velocity of discharge, which would exactly work up a given horse power. Knowing, there-

fore, the effluent velocity, we easily find the "head" of water corresponding to, or generating that velocity, and, knowing the head, it is easy to find the pressure within the jet. The presence of a column of sea-water 25½ feet high is 11¾ lbs. per square inch, and on the 904 square inches of the two jets this would amount to a total propelling force of 10,245 lbs. The real pressure urging the vessel forward was, as we shall presently see, very considerably less than this, as so far we have made no deductions whatever for loss of effect by friction, &c., either in the engines or water-passages. Resting for a moment with the quantities already obtained, the whole power would be utilized only when the vessel moved forward at the same rate as the effluent velocity of the jets, viz: 40½ feet per second, or 24 knots (of 6076 feet each) per hour. For the power is running away, so to speak, as the cube of the velocity of the jets, while the power utilized can only be as the cube of the velocity of the vessel, the pressure acting to drive the ship being, of course, as the square of the velocity of the jet, thus leaving the proportion of the power utilized to that expended in the simple ratio of the velocity of the ship to that of the jets. For the water-pressure within the passages leading to the jets is necessarily the same ahead and astern, while the work expended in one direction, and that usefully exerted in the other, must necessarily be as this pressure multiplied into the respective rates of motion in a unit of time. Now, the *Water-witch*, so far from moving at the rate of 24 knots per hour, or 40½ feet per second, went at 9 knots an hour, or 15 19 feet per second, and hence, in any case, nearly two-thirds of the power would appear to have been wasted.

But we cannot proceed upon the presumption that no power was lost in the friction of the engine, nor in the large centrifugal pump, nor in the friction of water in the passages, &c. Under all the circumstances, we cannot, as practical men, allow for the work actually done, in ejecting the jets more than one-half that indicated upon the engine pistons. In other words, the weight of water actually delivered would not, when multiplied into the height to which its effluent velocity would carry it, amount to more than one-half of the total number of foot-pounds corresponding to the 750 horse power actually indicated. We doubt even if this allowance for loss is sufficient; for the 14 feet centrifugal pump is one of the very worst form, having nearly radial blades, while the rate of motion to be imparted to the water is very great, and attended, therefore, with great friction. If, however, we throw off one-half only of the indicated power for all losses in the engines, centrifugal pump, and water-passages, the corresponding quantity of water discharged through the two jets would be nearly 12,120 cubic feet per minute, at an effluent velocity of 32 feet per second. This quantity of water, multiplied into the height to which its velocity of discharge would carry it, viz: 16 feet, would correspond very closely to 12,375,000 foot-pounds per minute, or 375 indicated horse power. The size of the jets remaining unaltered, no greater or less quantity could pass, at a greater or less velocity, to correspond to the 375 horse power. Now, a velocity of

32 feet per second, corresponding to a head of 16 feet of sea-water, pressing with a force of 7 lbs. per square inch, ahead and astern, is more than twice the actual rate attained by the vessel, its rate having been 15·19 feet per second. Hence, after first throwing off one-half of the total engine power as lost in friction, &c., we find that more than one-half of the remaining half was lost by reason of the inefficiency of the action of the jets.

Exception may be taken, however, to this mode of calculation, because it does not allow for the diminished co-efficient of discharge, as compared with the discharge theoretically due to a given water-pressure within the jet-pipe. Thus, while the water is actually running out at a velocity of say 32 feet per second, corresponding in theory to a head of 16 feet, and, therefore, to a pressure of 7 lbs. per square inch, the real pressure within the jet-pipe may be much higher, say 9 lbs. or 10 lbs., and thus the driving force upon the ship so much greater. It is here that more complete data are wanting. Thus the pressure as determined by a gauge on the jet-pipe, and the velocity of discharge, if that could be accurately obtained by a velocimeter, would enable us to ascertain exactly the proportion of power utilized. But it will be seen upon reflection that whatever may be deducted for the diminished co-efficient of discharge comes off the "duty" of the pump, and must form a further deduction beyond any we have yet made, although it is compensated by the superior pressure and consequently increased speed of the vessel, as compared with that theoretically due to the actual velocity of the discharge. We can best make this clear by referring back to the case already gone over. We have there made an allowance, founded upon the knowledge and experience of hydraulic engineers,—our own in common with others—for the combined loss from the friction of the engine, friction in pipes, and loss of effect in pump, this allowance being one-half of the total indicated horse power. This includes no allowance for the co-efficient of discharge, as compared with that theoretically due to the pressure in the jet-pipe. Let us, however, now suppose that the actual discharge is but three-fourths that theoretically due to the head. And whether this or any other proportion be taken, we shall find on trial that the final result is the same. The theoretical velocity, after allowing, as we have done, for friction, &c., was 32 feet per second, and three-fourths of this is 24 feet per second, so that the reduced rate of discharge through the two jets would give a delivery of about 9090 cubic feet per minute, and as the effluent velocity is but 24 feet per second, this would carry the water, *in vacuo*, to a height of 9 feet, and is therefore equal to lifting it to that height. But this lift represents but (9090 cubic feet $\times$ 64 lbs. per cubic foot $\times$ 9 feet high) 5,235,840 foot-pounds per minute, and, therefore, but 158½ actual horse power of work expended on the jets, whereas 750 was indicated upon the pistons. The pressure within the jet-pipes, acting to drive the vessel ahead, would still be 7 lbs. per square inch, and, at the speed attained on Friday's trial, this would amount to about 175 horse power actually utilized in propulsion, being still less than

one-fourth that exerted upon the pistons of the engines. And whether, after throwing off the first allowance of one-half for friction, &c., the pump (which we need hardly say is a "turbine," either in its construction or action) gave the full discharge due to the pressure within the jet-pipe, and thus imparted 375 horse power to the jets, or whether it gave a less discharge than that due to the pressure within the jet-pipes, and thus imparted less horse power to the jets, the driving power upon the vessel would be the same in either case, and would amount, in the case of Friday's trial, to but 175 horse power out of more than four times that amonnt of power indicated by the engines.

But we are told the *Water-witch* has gone nine knots an hour, and has done as well as a twin-screw gunboat, of the same size and form, called the *Viper*. We know nothing of the latter vessel, nor is she the *Viper* of 477 tons which appears in the last Admiralty tables of steam trials. If the twin-screw *Viper* has done no better than the *Water-witch*, she is indeed a poor affair, supposing the dimensions, power, &c., to be the same. On her trial last Friday the *Water-witch*, which is a badly shaped vessel, 162 feet long and 32 feet beam, had a mean draft of 9 feet 9 inches, an immersed midship section of 302 square feet, and a displacement of 1062 tons. With 750 indicated horse power, she went 9 knots, giving a co-efficient, by the midship formula, of 293½, and by the displacement formula of 101. We are not about to deny that even worse performances by very small screw vessels have been recorded; but we may compare the results obtained from the *Water-witch* with the recorded performances of other vessels of nearly the same size. The general comparison is in this case against the *Water-witch*, although not in all cases so much against her as to warrant the conclusion that the jet system has proved a decided failure.

Name of vessel.	Length.	Beam.		Mean draft.		Midship section.	Displacement.	Indicated horse power.	Speed.
	ft.	ft.	ins.	ft.	ins.	sq. ft.	tons.		knots.
Water-witch ...	162	32	0	9	9	302	1062	750	9·
Royalist.....	160	30	4½	14	0½	302	918	627	9·269
Rapid.....	160	30	4	13	10	293	894	505	8·888
Harrier.....	160	31	10	14	4	350	1047	360	8·32
Fawn.....	160	31	10	⅛	11½	230	1004	374	8·578
Cruiser.....	160	31	10	13	6½	332	1007	132	6·608
Columbine.....	160	30	4	13	10½	295	889	598	9·504
Alert.....	160	31	11	14	0½	333	1013	383	8·786
Shearwater.....	160	30	4	13	9	291	885	532	8·957
Fox.....	159½	40	4	16	3½	449	1340	741	9·325
Rinaldo.....	185	33	2	14	7½	367	1286	752	10·588
Serpent.....	185	28	4	11	4	254	840	692	9·724
Rattler.....	185	33	2	14	5½	360	1262	784	10·256
Chanticleer.....	185	33	2	13	10½	343	1185	701	10·01

We might extend this list to other vessels and to other trials of the same vessels, but we have chosen those in which the midship section was nearest to that of the *Water-witch*. Considering that the speeds are, roughly, about as the cube root only of the power, we think there can be no doubt, apart from the theoretical examination we have made, that the *Water-witch*, although it may have done better than was expected, has nevertheless given but a very poor result. Mr. Phipps, who has arrived at the same conclusion, by a different mode of reasoning, has written us a letter, which is worthy the attention of our readers.

H. M. S. Water-witch.

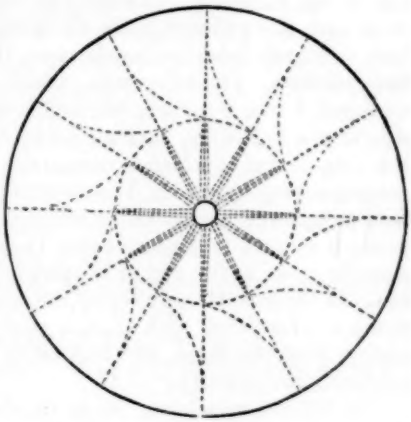
From the London Engineering, No. 43.

In the preceding columns we give an analysis of the result obtained, during her trial on Friday last, by H. M. S. *Water-witch*, a steam sloop fitted with Ruthven's hydraulic propeller, and we propose now to describe the machinery with which the vessel is fitted. A general account of the *Water-witch* and her propelling machinery appeared in this journal some months ago, (*vide Engineering*, vol. i., page 407.) The *Water-witch* was designed by Mr. E. J. Reed, and, as we stated in our former notice, she has been built by the Thames Iron Works and Shipbuilding Company. Her tonnage is 778 tons measurement, her length being 162 feet, her breadth 32 feet, and her depth 13 feet 9 inches. She has a flat bottom and is double-ended, each end being fitted with a rudder. She is armor-plated, for a length of about 60 feet amid-ships, with 4½-inch plates, placed upon 10-inch teak packing, this armor-plating extending from about 3 feet below to 4 feet above the water-line, and at the forward and aft end of this central armor-plated portion, armor-plated bulkheads are carried across the vessel, that at the after end reaching only as far as the upper deck, whilst that at the forward end extends 5 feet 6 inches above it. This forward bulkhead is furnished with ports, so that guns may be pointed through it in a line with the keel and fired over the upper deck, the vessel being capable of being fought end on.

The propelling machinery was constructed by Messrs. J. and W. Dudgeon, according to the plans of Mr. Ruthven, and its arrangement consists of a set of three-cylinder condensing engines driving a centrifugal pump, by which the water is supplied to the jets which form the propelling power. Four parallel passages, made of boiler-plates and angle-irons, conduct the water to the centrifugal pump, the water being admitted into these passages through a number of gill-like openings formed in the forepart of the bottom of the vessel. These openings, which are very close together, were formed by cutting a number of transverse slits in the bottom plates, and then "dishing" up the metal between them, the amount that the plates are dished or bulged upwards increasing from the after-side of each slit to the foreside of the

one abaft of it. In this manner there are formed a number of openings of a segmental shape, the arched top of each being formed by the dished plate and the lower or straight edge by the unbent portion of that part of the plate which is dished to form the next opening. The plates in which the openings are formed are of Lowmoor iron. The parallel passages leading from the openings to the pump are each 3 feet 1⅜ inches wide by 1 foot 11½ inches deep in the clear, and they are each fitted with a sluice-valve by which the amount of water admitted can be regulated. The two outside passages are also fitted with sluice-valves, by means of which they can be placed in communication with the bilge, so as to draw their supply of water from it if necessary. Under the centrifugal pump the waterways are curved round in a spiral form, and their ends are furnished with inclines which assist in conducting the water smoothly up to the wheel of the centrifugal pump.

The revolving wheel of the centrifugal pump is 14 feet in diameter at the top, and 14 feet 3 inches in diameter at the largest part, and it has twelve arms, these arms, which curve both upwards and outwards, being secured by their edges to conical disks which form the upper and lower faces of the wheel. The water is guided by the waterways to a central opening at the underside of the wheel, and, being raised by the action of the latter, is delivered into a cast iron casing within which the wheel revolves. The lower central opening of the wheel is 6 feet in diameter, and the annular opening through which the water is discharged is 1 foot 10½ inches deep, whilst the total depth of the wheel is 4 feet 8½ inches. The wheel is made of wrought iron plates and angle-irons. From the wheel-case the water is conducted through two copper pipes, which leave the case tangentially, and are led with a spiral curve to the jets at the side of the vessel. The arrangement employed for directing the jets, either backward or forward, consists of a large two-way cock placed at each side of the vessel just within the delivering nozzles, and by turning these cocks the water can be delivered through either the forward or aft nozzles, or through one forward and one aft nozzle at pleasure. The cocks can be worked from the deck-level by means of suitable gearing. The delivering nozzles, which are situated close to the water-line, are of brass, and are protected by armor-plating. Their size is 2 feet 1 inch by 1 foot 7 inches, and their corners being rounded, their area is equal to that of a circle 2 feet in diameter, or about 452 square inches.



The engines first designed for driving the pump had two cylinders, each 44 inches in diameter with 4 feet stroke; but this design was departed from, and the three-cylinder arrangement adopted. The three cylinders, which are each 38½ inches in diameter, with a stroke of 3 feet 6 inches, are placed horizontally, and are arranged so that their centre lines form angles of 120° with each other. Each cross-head works on a single slide placed on one side of it, and the three connecting-rods are all coupled to a single crank formed on the vertical shaft of the revolving wheel. Each of the journals of the shaft is furnished with a series of collars like the thrust bearing of a screw-shaft, these collars supporting the weight of the wheel, and resisting the downward pull caused by the action of the wheel upon the water.

The slide-valves are of the ordinary double-ported kind, and are contained in valve-chests placed above the cylinders. They have 1 inch lap and ⅛ inch lead, and are all driven by a single eccentric of 3 inches throw, placed on the vertical shaft above the crank. The eccentric rods are coupled direct to the valve-spindles, there being no expansion gear, and reversing gear not being required, as the engines are always run in one direction. The cylinder steam-ports are 27 inches by 1 1/16 inch, and the exhaust-ports 27 inches by 4½ inches. The engines have ordinary injection condensers, these being placed by the side of the cylinders. The air-pumps, which are 18 inches in diameter with a stroke of 1 foot 9 inches, are double-acting, and are also placed by the side of the cylinders, each air-pump being driven by means of a lever, the longer arm of which is connected by links to the cross-head of the corresponding cylinder. The air-pump valves are of india rubber. The feed-pumps are conveniently arranged in front of the air-pumps, the plunger of each feed-pump being reduced in diameter, and led through a stuffing-box at the end of the pump-barrel, so as to form the air-pump rod. As we have already stated, the side waterways leading to the main pump are furnished with sluices, so that they can be made to take their supply from the bilge, and this being the case, other bilge-pumps are rendered unnecessary.

The boilers, which are two in number, are placed abaft the engines, the tubes and furnaces running fore and aft, and the stoke-hole being abaft the boiler. Each boiler is 11 feet wide, transversely, by 10 feet 6 inches high, and the length of each is 9 feet at the bottom and 9 feet 8 inches at the top, whilst a space 3 feet wide is left between the pair. There are three furnaces in each boiler, each furnace being 3 feet wide by 3 feet high, and the grate bars being 6 feet 6 inches long. The back uptake is 1 foot 6 inches wide, and from it the tubes return over the furnaces in the usual manner, each boiler containing 358 tubes, 5 feet 10 inches long and 2⅛ inches in diameter. The coal is carried in bunkers extending across the vessel ahead and abaft the engine room.

The Breaking of Railway Axles. By Henry Simon.

From the London Engineering, No. 43.

The following extract from an official paper issued by the Association of German Railways, on broken axles, in 1865, may be interesting:

The returns are from twenty-three railway companies, and give a total number of one hundred and fifty-three breakages, besides forty cases discovered before complete breakage occurred.

Of these one hundred and fifty-three cases, thirty-four happened in September, October, November; forty-five in December, January, February; thirty-six in March, April, May; thirty-eight in June, July, August.

The average time of use before breakage was nine years and eleven months.

The longest time was twenty-one years four months.

The shortest only five months.

The average mileage was 104,780 English miles.

The greatest mileage was 332,580 English miles.

The axles were:

			English miles.
In 17	cases of	cast steel, and ran an average of	85,171
1	case of	cast steel (hardened)	93,339
46	cases of	wrought iron (hammered)	114,575
38	"	wrought iron (rolled)	103,311
48	"	wrought iron (not stated whether rolled or hammered)	131,918
3	"	hollow axles	90,252

The consequences of the breakages were:

In 5 cases the carriage or wagon got off the line, without any damage.

In 37 cases the carriage was more or less damaged.

In 9 cases several carriages were damaged, including one case where 19 carriages were injured.

No lives were lost.

98 cases happened with trains at full speed.

16 cases near stations, *i.e.*, at low speed.

24 cases were found out during the stoppage of trains in stations.

15 cases occurred during shunting.

The probable cause of breakage was:

In 17 cases bad workmanship of axle.

In 32 cases bad material

In 21 cases bad design.

In 6 cases overloading.

In 10 cases want of grease or oil.

In 46 cases too long use.

In 3 cases breakage of another axle.

MECHANICS, PHYSICS, AND CHEMISTRY.

A New Era in Illumination.— Wilde's New Magneto-electric Machine.

By WILLIAM CROOKES, F.R.S.

From the London Journal of Science, October, 1866.

In the first number of this *Journal*, an article "On Light-house Illumination by Magneto-electricity" was contributed by Dr. Gladstone. Nearly three years have elapsed since that time, and a very important result in this branch of science having recently been obtained, it seems a fitting opportunity again to draw attention to the subject as an introduction to our more immediate topic.

The experience of the last two or three years in the use of the electric spark in light-houses has brought prominently forward several disadvantages and objections under which it labors. The advantages are many and obvious, and were well summarized in Dr. Gladstone's article, and were amply sufficient to justify the English authorities in persevering attempts to introduce this light into practice. In 1855, while corresponding on this subject with the late hydrographer to the Admiralty, Admiral Washington, Mr. T. Stevenson stated: "What we want is powerful apparatus, not intricate distinctions. To be enabled to see a light in a thick night, though it be only half a mile further than at present, may be of incalculable moment. If, therefore, we can increase the power of our lights so as to make them pierce the gloom but that fraction of a mile further than they do at present, we are moving in the right direction. On that small amount of extra offing hundreds of lives may depend." It would appear as if the electric light was pre-eminently adapted to meet a case like this; but recently doubts have been thrown on its superiority over oil in penetrating fog. In 1865, Mr. Berthon, the Secretary to the Trinity House, said, that, for a limited range of from nine to ten miles, the electric is immensely superior to any other light, but beyond that distance it appears to lose in a great degree its power, until at eighteen or twenty miles it is not very different to any ordinary first-class light; and Mr. Stevenson likewise states, that at great distances the oil light maintains its power better than the electric. Such a phenomenon certainly seems to be very improbable, although it may be the case that the rays proceeding from the electric light suffer so much more from absorption, in passing through an obstructive medium, than those from a flame produced by the consumption of oil, as to leave the oil light the more powerful of the two at great distances. If this were really so, it would follow that the application of the electric spark to light-house illumination is based upon a fallacy. The mere glare or splendor of effect to a near observer, so far from being an advantage to the mariner, is a positive evil, because, by its lustre, it tends to destroy his powers of perception of objects in the water that are nearer his view, and which, therefore, from their proximity, threaten more immediate danger to the safety of his vessel. All the mariner requires is distinct visibility. The really useful

power is that of penetration through an obstructing medium, and, therefore, the true measure of the usefulness of any light is the distance to which it remains distinctly visible, and at which it preserves its characteristic appearance. This objection to the electric light has only been made within the last year or so, and is apparently irreconcilable with the statements respecting its brilliant visibility at great distances, upon which so much stress was laid on its first introduction.

Other difficulties have also been met with. The kind of knowledge and attention required to render the magneto-electric light constant and sure is far above that necessary with the most elaborate oil lamp; and the uncertainty to which the use of machinery of any kind is inherently liable, independently of the necessity of maintaining a constant supply of water, and the great difficulty of repairing and renewing the steam engines and magneto-electric machines when required, all contrast most unfavorably with the certainty and simplicity attending the present oil lamp system. To this must be added the constant difficulty experienced in maintaining a class of persons for so responsible an office as that of engineer or attendant. A light-house, from its special nature, its great importance, its uninterrupted action, and its isolated position, is, in the language of Dr. Faraday, the last place to which processes comparatively new in their nature should be applied, if there be any other educational positions which can precede such application. Now, in spite of all the care which the importance of the subject has rendered necessary, the Dungeness electric light entirely failed or was inefficient for upwards of 119½ hours, between August, 1863, and October, 1864; and, referring to this, the Elder Brethren of the Trinity House say that it appears to them to be impossible to obtain entire immunity from such accidents, so long as human nature is subject to infirmity. These fallings off and cessations have frequently rendered it necessary that the ordinary oil lamps should be lighted, and, notwithstanding the power of the magneto-electric light, instances have occurred of vessels being stranded near Dungeness. This liability to occasional failure is a matter for grave consideration in respect to the development of the magneto-electric light as an element of light-house illumination.

Under these circumstances the Elder Brethren stated, on January the 18th, 1865, in answer to an inquiry from the Marine Department of the Board of Trade, that they are induced "to adhere to the opinion expressed to their Lordships in their letter of the 8th of April, 1863, that they are not prepared to recommend the adoption of the magneto-electric principle for light-house illumination." This opinion was repeated on the 15th of March, 1865, when the Secretary of the Trinity House wrote as follows:

"There are numerous other causes of minor importance which have led the Elder Brethren to the decision expressed in my letter of the 18th of January, which can only be duly weighed and appreciated by those on whom the responsibility of working, and, above all, of maintaining the lights is placed, and, as already expressed in their letter of 8th

of April, 1863, the Elder Brethren feel that there are no advantages which can counterbalance the want of certainty in light-house illumination."

Meantime, a somewhat modified system of illuminating light-houses by electro-magnetic apparatus has been successfully exhibited at Havre, in France, and the Commissioners of Northern Light-houses suggested that their engineer should be sent over to report upon it. It appeared that the plan adopted was very similar to that of Mr. Holmes, and that M. Berlioz had only made a few improvements upon it. Mr. Holmes being of opinion that he could now supply a better machine than the one in use at Havre, it was considered that it would be a national discredit and an act of injustice to that gentleman, if, under these circumstances, the foreign system were adopted. It was therefore decided at the latter end of last year that an entirely new system of apparatus, including lamp, machines, and engine, should be procured from Mr. Holmes; that the eminent optical engineer, Mr. James Chance, should be asked to put into practice certain opinions which he has always held respecting the size of the lens required, and the arrangement of curvature, he undertaking to supply an instrument which should be entirely suitable, whilst the Elder Brethren proposed to combine with this new apparatus a thoroughly independent system of management, which they trust may result in the establishment of the magneto-electric light as a useful component of light-house illumination.

Early in the present year, rumors of Mr. Wilde's new electro-magnetic apparatus were first heard, and Mr. Thomas Stevenson was instructed to visit Manchester to report on the same. He was so very favorably impressed with the apparatus, that it was considered indispensable to a proper series of experiments that it should be tested along with Professor Holmes'. An estimate was accordingly obtained from Messrs. Wilde, and their offer was at once accepted.

The light from Messrs. Wilde's large machine, which Mr. Stevenson saw, is the most powerful artificial light which has ever been produced, giving about eight times the light of the magneto-electric machines now in operation, and it was therefore not considered desirable to suggest the use at present of that sized machine for light-house purposes. A machine about half the power of the large one was recommended, as by a simple arrangement the brilliancy of the light, and the power required to drive the machine, could be varied at pleasure, to suit the different conditions of the atmosphere, and with it requirements could be met which would be beyond the power of any other description of machine. The dimensions of such a machine would be—length 64 ins., width 20 ins., height 48 ins., and the cost £1,000. Ultimately a machine of half this power, to cost £500, was decided upon, and when the writer had the pleasure of visiting Messrs. Wilde's workshops, and the advantage of listening to the inventor's lucid description of his large machine, the one being made for the Commissioners of Northern Light-houses was far advanced towards completion.

Like most practical applications of science, the important results

which Mr. Wilde has obtained depend more upon an ingenious combination of several known facts, united with considerable engineering skill, than upon any really new and striking discovery in the science. The principle of the machine can be expressed in a few words. It consists in the application of the current from an electro-magnetic machine, armed with permanent magnets, for the purpose of exciting a powerful electro-magnet; this electro-magnet being now used as the basis of a still larger electro-magnetic machine, for the purpose of having induction currents generated by its agency. In other words, by well-known means, an electric current can be obtained by the rotation of an armature close to the poles of a magnet. If this electric current be passed round an electro-magnet, it may be made to produce a far greater amount of magnetism than was possessed by the first magnet. There is no difficulty, therefore, in comprehending how, by the mere interposition of a rotating armature, and the expenditure of force, a small and weak magnet may be made to actuate a very powerful magnet. But as the power of the magnet increases, so does the power increase of the electric current which may be generated by induction in an armature rotating between its poles. We have, therefore, only to pass this No. 2 induced current from No. 2 magnet round a still larger magnet No. 3, and by rotating an armature between its poles we can get a still more energetic induced current No. 3. Theoretically there is no limit to this plan. It is a species of involution; and when it is considered that each conversion from magnet No. 1 to magnet No. 2, &c., or from induced current No. 1 to induced current No. 2, &c., multiplies the power very many times,* it will not be considered surprising that after three involutions the induced current possesses such magnificent powers.

Some erroneous opinions are pretty generally entertained as to the actual discovery claimed by Mr. Wilde, and the splendor of the result, for achieving which he deserves the very highest credit, is liable to cause early investigators in the field to be overlooked. This would be most unfair; for it is through their instrumentality that the way has been paved for the success now achieved. In 1838 the Abbés Moigno and Raillard† proved that, by taking an electro-magnetic machine, the original magnet of which would only support a few grammes, and passing the electric current generated by it round a large electro-magnet, the latter could be made to support a weight of 600 kilogrammes. The Abbés carried the multiplication of power only so far as to obtain the more powerful magnet No. 2 from the weak magnet No. 1.

Electro-magnets of extraordinary power, with coils arranged longitudinally, instead of transversely, on their armatures, had been made by Mr. Joule. Magneto-electric machines, with revolving armatures, in which electro-magnets had been substituted for permanent magnets, had been constructed by Dr. Page and Prof. Wheatstone. Magneto-

* We say very many, but we have absolutely no data to guide us to a near approximation.

† Moigno's "Télégraphie Electrique," page 15. Paris: 1849.

electric machines had been made to act on electro-magnets in various telegraphic instruments by Wheatstone, and subsequently by others; and Dr. Page, as well as the experimentalists above mentioned, had observed the important fact that an electro-magnet excited by a magneto-electric machine became capable of effects greatly exceeding those of the original magnet. The peculiarly constructed armature employed by Mr. Wilde is likewise essentially identical with Siemens' helix, a full description of which may be seen in Siemens' patent, and also in the fifth volume of Du Moncel's "Applications de l'Electricité," page 249, published in 1862. It is, however, right to say, that Mr. Wilde, in his patent of February 25, 1863, expressly states that he makes no claim to the peculiar construction of the armature.

By the kindness of Mr. Wilde, we are enabled to give our readers a full description, with drawings, of the machine now in process of manufacture for the Northern Light-house. Plate V., Fig. 1 represents a side view, and Fig. 2 an end view of the machine, the letters referring to the same parts in each, *a a a a a* are 16 permanent magnets, bolted on to the magnet cylinder *b*, shown in magnified section at Fig. 3. The magnets weigh about 3 lbs. each, and will support a weight of about 20 lbs. In the magnet cylinder the part *b b* is iron and *c c* brass, and it is so arranged that *b b*, being screwed on to the respective poles of the magnets at *d*, form one entire north pole and one entire south pole to the 16 magnets, separated from each other by the brass pieces *c*. A circular hole, 2½ inches in diameter, is bored lengthways through the metals, so as to form them into a hollow cylinder of brass and iron. Fig. 4 represents the armature, a transverse section of which is also shown in its place inside the hollow cylinder, Fig. 3. It consists of a cylinder of cast iron, about one-twentieth of an inch less in diameter than the hole in the cylinder *b c b c*, so that it may revolve in very close proximity to the interior of the hollow cylinder without touching it, being held at each end by appropriate brass supports, in which the axis of the cylinder works. At one end of the armature is a cylindrical prolongation *d*, on which a pulley *e* works, and at the other end is fixed a commutator. About fifty feet of insulated copper wire, one-eighth of an inch in diameter, are wound upon the armature in the direction of its length, as shown in Fig. 4, and in section in Fig. 3. The inner extremity of the wire is fixed in good metallic contact with the armature, the other end being connected with the insulated half of the commutator. Bands of sheet brass, *f f*, are bound at intervals round the armature, in grooves sunk in it for that purpose, their object being to prevent the convolutions of insulated wire from flying out of position by centrifugal force when in rapid rotation.

By means of the small strap *e* the armature is made to revolve in the interior of the magnet-cylinder at about 2500 revolutions per minute. During each revolution, two waves of electricity, moving in opposite directions, are induced in the insulated copper wire surrounding the armature. The rapid succession of alternating waves thus generated at the rate of 5000 per minute are, by means of the commutator

WILDE'S MAGNETO ELECTRIC MACHINE

Fig 2

Fig 3

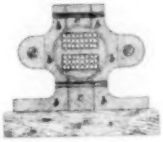


Fig 4

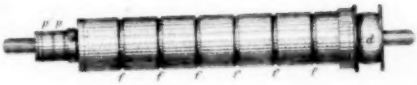
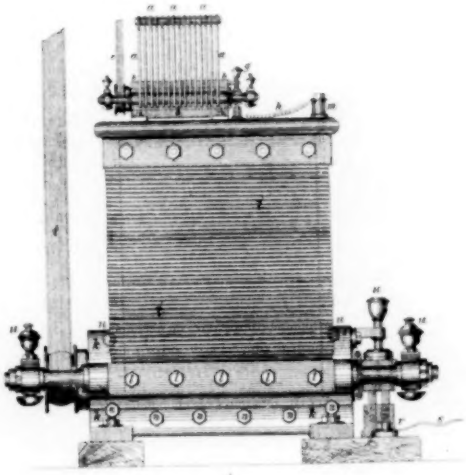


Fig 1



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at *g*, converted into an intermittent current moving in one direction only, which is conducted along the wires *h*.

The electro-magnetic machine by which the light is produced is of precisely the same construction as the magneto-electric machine just described, except that an electro-magnet *i* is substituted for the permanent magnets *a a*. The electro-magnet *i*, Figs. 1 and 2, is formed of two rectangular plates *j* of rolled iron, 36 ins. in length, 26 ins. in width, and 1 in. in thickness, as shown by the dotted lines. They are bolted, parallel with each other, to the sides of the magnet cylinder *k* by means of the bolts *l*, and the plates are connected together at their upper extremities by being bolted to a bridge formed of two thicknesses of the same iron as that of which the sides are made. All the component parts of the electro-magnet, requiring to be fitted together and to the magnet cylinder, are planed to a true surface, for the purpose of ensuring intimate metallic contact throughout the entire mass.

Each of the sides of the electro-magnet is coiled with an insulated conductor, consisting of a bundle of seven No. 10 copper wires, laid parallel to each other, and bound together with a double covering of linen tape. The length of conductor coiled round each side of the electro-magnet is 1650 feet. Two of the extremities of the coils are connected together so as to form a continuous circuit 3300 feet in length. The other extremities of the coils terminate in the two insulated metal studs *m m*, fixed upon the wooden top of the machine, and connected thereby with the wires *h h*. The total weight of the two coils of insulated copper wire, without the iron, is half a ton. The diameter of the hole in the magnet cylinder is 7 ins., and its length 35 ins. The separate parts of the cylinder are bolted together at the top and bottom by means of 12 copper bolts *n*, three-quarters of an inch in diameter. The armature *o*, which is an exact fac-simile, except as regards size, of the one already described, is about one-eighth of an inch less in diameter than the bore of the magnet cylinder. It is wound with an insulated strand of copper wire, 350 feet in length and a quarter of an inch in diameter, as shown in section in Fig. 3. A pulley *d*, 7 inches in diameter, is keyed upon one end of the armature, and upon the other end are fixed two hardened steel collars *p p*^{1}, one of which is insulated from the armature axis. These form part of the commutator, by means of which the rapidly alternating currents are converted into an intermittent current moving in one direction only. These currents of electricity, which produce the light, are taken from the steel collars by means of the springs *q q*, and thence to the screw nuts at *r*, from which they can be conveyed to any place required by the conductors *s s*.

The armature of the 7-inch machine is driven at 1800 revolutions per minute by means of the strap *t*, from the same shaft as the magneto-electric machine. Reservoirs for oil are shown at *u*. The total weight of the machine complete is a little more than 1 ton.

The action of the machine will be readily comprehended from the explanation previously given. The electricity induced from the permanent magnets *a a a*, in the rotating armature of the small machine,

is transmitted, by means of the wires *h h*, through the coils of the large electro-magnet of the 7-inch machine, the iron plates and magnet cylinder of which acquire an enormous amount of magnetism. Simultaneously a porportionately larger amount of electricity is induced in the wires of the larger armature, and this current of electricity is used for producing the light. When the machine is in full action, an engine of about three horse power will be required to drive it, and the lamp will consume sticks of carbon at least $\frac{3}{8}$ inch square. The power of the machine may be regulated according to the quantity of light required to suit the different conditions of the atmosphere, by placing small blocks of iron on the top of the small magnet cylinder *b b*, so as to connect the opposite poles, and proportionately diminish the power of the induced current in the armature.

This machine is, as already mentioned, considerably smaller than the one now in existence. In the former there are only two conversions; that is to say, a permanent magnet—an induced current of electricity—an electro-magnet—a more powerful induced current. In the large machine there is a still further multiplication of force. Its small magneto-electric machine has an armature of $1\frac{5}{8}$ inch diameter, armed with six small permanent magnets, weighing 1 lb. each. The induced current from this is transmitted through the coils of the electro-magnet of a 5-inch* electro-magnetic machine, and the direct current from the latter is simultaneously, and in like manner, transmitted through the coils of the electro-magnet of a 10-inch machine. The weight of the electro-magnet of the 10-inch machine is nearly three tons, and the total weight of the instrument is about $4\frac{1}{2}$ tons. The machine is furnished with two armatures—one for the production of "intensity" and the other for the production of "quantity" effects. The intensity armature is coiled with an insulated conductor, consisting of a bundle of thirteen No. 11 copper wires, each 0·125 of an inch in diameter. The coil is 376 feet in length, and weighs 232 lbs. The quantity armature is enveloped with the folds of an insulated copper plate conductor 67 feet in length, the weight of which is 344 lbs.

With the three armatures driven at a uniform velocity of 1500 revolutions per minute, an amount of magnetic force is developed in the large electro-magnet far exceeding anything which has hitherto been produced, accompanied by the evolution of an amount of dynamic electricity from the quantity armature, so enormous as to melt pieces of cylindrical iron rod fifteen inches in length and fully one-quarter of an inch in diameter, and pieces of copper wire of the same length and one-eighth of an inch in diameter. With this armature in, the physiological effects of the current can be borne without inconvenience; immediately after 15 ins. of iron bar had been melted, the writer grasped the terminals, one in each hand, and sustained the full force of the current. The shocks were certainly severe, but not inconveniently so.

When the intensity armature was placed in the 7-inch magnet cylin-

* For the sake of convenience, the different sized machines are distinguished by the calibre or bore of the magnet cylinders.

der, the electricity melted 7 feet of No. 16 iron wire, and made a length of 21 feet of the same wire red-hot. The illuminating power of the current from this armature was of the most splendid description. When an electric lamp, furnished with rods of gas-carbon half an inch square, was placed at the top of a lofty building, the light evolved from it was sufficient to cast the shadows of the flames of the street-lamps, a quarter of a mile distant, upon the neighboring walls. When viewed from that distance, the rays proceeding from the reflector have all the rich effulgence of sunshine. With the reflector removed from the lamp, the bare light is estimated to have an intensity equal to 4000 wax candles. A piece of ordinary sensitized paper, such as is used for photographic printing, when exposed to the action of the light for 20 seconds, at a distance of 2 feet from the reflector, was darkened to the same degree as a piece of the same sheet of paper was when exposed for a period of one minute to the direct rays of the sun at noon on a very clear day in the month of March. The day on which the writer saw the machine at work, (towards the end of June,) the mid-day sun was shining brightly in at the window. He took the opportunity of roughly comparing the intensity of the sun with that of the electric light armed with the reflector. From a comparison of the shadows thrown by the same object, it appeared to him that the electric light had between three and four times the power of the sunlight. That the relative intensities were somewhat in this ratio, was evident from the powerful scorching action the electric light had on the face, and the ease with which paper could be set on fire with a burning-glass introduced in the path of its rays.

The extraordinary calorific and illuminating powers of the 10-inch machine are all the more remarkable from the fact that they have their origin in six small permanent magnets, weighing only 1 lb. each, and only capable at most of sustaining collectively a weight of 60 lbs. When working up to its full intensity, it requires an engine of about 7 horse power to drive it.

The physicist will, at first sight, consider that the intimate connexion between the consumption of so large an amount of mechanical power, and the evolution of so enormous an electrical force, is a necessary consequence of the modern doctrine of the conservation of force. But, without for a moment denying the truth of this doctrine, it must be admitted that there are certain phenomena connected with this machine which are in apparent contradiction to the law of conservation.

A phenomenon already obtained on a small scale by Jacobi, Lenz, and Miers, is rendered visible in the most striking manner by means of this machine. When the wires, forming the polar terminals of the small exciting magneto-electric machine, were connected for a short time with those of the large electro-magnet, and then disconnected, a bright spark could be obtained, from the wires of the electro-magnet, 25 seconds after all connexion with the magneto-electric machine had been broken.

It will be of interest, apart from all questions as to economical production, to ascertain what is the theoretical quantity of coal required

to be consumed in the production of this amount of electric force. Mr. Wilde says that a 7 horse power engine is required to drive the machine. One horse power is equal to 1,980,000 foot-pounds per hour; that multiplied by seven is 13,860,000 foot-pounds per hour, which therefore represents the actual power required to drive the machine. Now, by multiplying the British Fahrenheit units of heat produced by the combustion of one pound of coal, by Joule's equivalent, or 772 foot-pounds, the result will be the total heat of combustion expressed in foot-pounds. In the best coal this is as high as 12,000,000 foot-pounds. We arrive, therefore, at the startling conclusion, that, to overcome the friction of the different parts of the machine; to whirl a mass of metal, weighing several hundred weights, round with a velocity of 1500 revolutions per minute; to generate a current of electric force far surpassing anything ever before produced; and, after allowing for the waste inherent in its passage through the conducting wires and electric lamp, to cause it to blaze forth with an intensity of light, before which the rays of the sun himself appear pale and feeble; to keep up this intense development of energy for one hour, requires an expenditure of force represented by the combustion of less than 18½ ounces of coal!

This is the theoretical calculation; but if reduced to actual practice, the results are scarcely less astonishing. The economy of the power actually employed by Mr. Wilde cannot be calculated, as the engine is a 60 horse one, and is used for driving the very heavy machinery of a wire mill, as well as performing the various operations required in an engineer's workshop; but the *efficiency* of an engine, *i.e.*, the ratio of the work actually performed to the mechanical equivalent of the heat expended, is well known, and varies in extreme cases between the limits 0·02 and 0·2. Taking an average efficiency as 0·1, or one-tenth, we find that the ordinary consumption of coal required to work a 7 horse power engine, midway between excessive wastefulness on the one hand, and rigid economy on the other, is $10 \times 18\frac{1}{2}$ ounces, or $11\frac{1}{2}$ lbs. of coal per hour, worth about one halfpenny.

The above expense of one halfpenny per hour for coal is, of course, only one item in the cost. To it must be added the expense of carbon rods for the lamp, which will be about 10 ins. per hour, worth perhaps a penny. There must also be added interest of the cost of purchase of machines, expense of maintenance and repairs, which will perhaps bring up the total expense per hour to sixpence or eightpence. Comparing this with the hourly expense of the electric lights already in existence, we find, according to the Abbé Moigno, that the French machine costs altogether sixpence per hour for a light equal to 900 wax candles, whilst the actual working expenses of maintaining the electric light at Cape La Hève, during a period of 27 months, have been, exclusive of salaries, about one shilling per hour, or, inclusive of salaries, two shillings.*

According to a calculation made by the Abbé Moigno, respecting

* "Mémoir sur l'Eclairage et la Balisage des Côtes de France," par M. L. Reynaud, p. 149. Paris: 1865.

the economy of the light evolved by the French machines, and altering the figures to suit the present case, it appears that to maintain a light equal to 4000 wax candles for one hour, would cost, with gas, £1 2*s* 6*d*.; with Colza oil, £1 7*s*.; and with the electrity produced by a Bunsen's pile, £1 15*s*. 6*d*.

The annual expenditure at a first-class light-house, on the old system, is, on an average, £400 per annum, and, on the assumption that the light burns for 4000 hours per annum, that would come to two shillings per hour. The expenses of the old and the electric system are, therefore, not very dissimilar, and the problem of the adoption of electricity to supersede oil must be decided on grounds of convenience and efficiency alone.

The great advantage of Mr. Wilde's over the old system of magneto-electric machine, appears to be that it is capable of amplification to any required power, by a mere enlargement of the size of the different parts. His largest machine weighs about 3 tons. If, instead of using the electric current generated by it to produce dynamic effects, we pass it round a still larger electro-magnet, we should at once produce a vastly greater development of force. The only limit which we see to this multiplication of power, is the excessive heat which would be developed in the rotating armatures. It would be an interesting problem to calculate what would be the result of driving the 32-inch armature, required for a 100-ton magnet, with (say) a 1000 horse power steam engine. If the power generated by this machine did not at once burn up the working parts, dissipate the electric lamp and conducting wires with a mighty explosion into space, and strike dead all the attendants with one lightning flash; if it were at all manageable, and were put on a high tower, it would probably give light enough to make London by night considerably brighter than London by day.

Space will not admit of the enumeration of all the uses to which so convenient and economical a light may be applied. Moreover, this is a subject which has been so frequently discussed that any enumeration here would become a mere repetition. One practical application has, however, been made, which possesses great interest. Photographers are finding that it is more convenient than the sun. According to the *Photographic News*, we learn that an establishment has been organized at Manchester, in which is fitted up the first of Mr. Wilde's machines for supplying the electric light. By the aid of this, more than two hundred negatives can be exposed in a day, to secure gelatine reliefs. This is the first practical application of the electric light to the commercial working of photography, its constancy rendering it here more valuable than an uncertain sunlight.

The purely scientific interest of this discovery has been scarcely touched upon. Of this more will be said hereafter. To physicists and experimentalists in magnetism the gigantic magnetic force developed in the 3-ton magnet will afford an opportunity, which will doubtless at once be seized, of repeating and extending the classical researches of Dr. Faraday in Diamagnetism and the Magnetic Condition of all Matter.

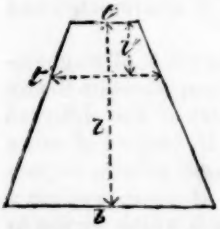
For the Journal of the Franklin Institute.

Problems in Mensuration.

To divide the surface of a trapezoid into any number of equal parts, by lines parallel to the top and bottom.

Call l'' the length of first part from top; then, if it is divided into two parts, we have—

$$l''=\left(\sqrt{\frac{b^2+t^2}{2}}-t\right)\frac{l}{b-t},$$ and for five parts $$l''=\sqrt{\frac{b^2+4t^2}{5}}-t\Big)\frac{l}{b-t},$$



$$l'''=\sqrt{\frac{2b^2+3t^2}{5}}-t\Big)\frac{l}{b-t},$$

$$l^{\text{IV}}=\sqrt{\frac{3b^2+2t^2}{5}}-t\Big)\frac{l}{b-t},$$

$$l^{\text{V}}=\sqrt{\frac{4b^2+t^2}{5}}-t\Big)\frac{l}{b-t},$$

And the value of t'', t''', &c., is always the corresponding quantity under the radical.

When the figure is an isosceles triangle, the value of $t=0$, and the formulas reduce to simpler forms.

To divide the frustrum of a cone or pyramid into equal parts, by planes parallel to top and bottom.

Into two parts, $$l''=\left(\sqrt[3]{\frac{b^3+t^3}{2}}-t\right)\frac{l}{b-t}.$$

Into five parts, $$l''=\left(\sqrt[3]{\frac{b^3+4t^3}{5}}-t\right)\frac{l}{b-t},$$

$$l'''=\left(\sqrt[3]{\frac{2b^3+3t^3}{5}}-t\right)\frac{l}{b-t},$$

$$l^{\text{IV}}=\left(\sqrt[3]{\frac{3b^3+2t^3}{5}}-t\right)\frac{l}{b-t},$$

$$l^{\text{V}}=\left(\sqrt[3]{\frac{4b^3+t^3}{5}}-t\right)\frac{l}{b-t}.$$

And the value of t'', t''', &c., is always the corresponding quantity under the radical.

In case of a cone or pyramid the value of $t=0$, and the formulas reduce.

To increase the solidity of a frustrum of a cone or pyramid any number of times by addition to the large end.

To double it, $$l'=(\sqrt[3]{2b^3-t^3}-t)\frac{l}{b-t}.$$

To quintuple it, $$l'=(\sqrt[3]{5b^3-4t^3}-t)\frac{l}{b-t}.$$

To double the area of the figure by prolonging the sides with a new base, parallel to the top and bottom.

$$l' = (\sqrt{2\,b^2 - t^2} - t)\frac{l}{b-t}.$$

To quintuple, $l^v = (\sqrt{5\,b^2 - 4\,t^2} - t)\frac{l}{b-t}$.

And the *quantity under the radical* is the length of the new base.

G. D.

Waste of Platinum in Sulphuric Acid Manufactories.

From the London Mechanics' Magazine, April, 1866.

Some few years ago M. Scheurer-Kestner, of Thann, made some careful researches as to the *amount* of the waste of platinum in sulphuric acid manufactories in which platinum alembics were used, and he found that, in an apparatus which, when regularly worked, yielded 4000 kilogrammes of concentrated acid per day, each 1000 kilogrammes of acid dissolved and carried away about two grammes of platinum, when the acid was tolerably free from nitrous vapors, and as much as four or five grammes of platinum when the acid was no freer from nitrous vapors than it is usually. He accordingly recommended that sulphate of ammonium should always be added to the sulphuric acid in the alembic, that salt being decomposed by the nitrous vapors, and its base combining with them and thereby rendering them inert. He found that the waste of platinum was very greatly diminished when this expedient was adopted. He found, too, that *new* alembics undergo less rapid waste than those which have been in use for some time, freshly-hammered platinum being more compact, and so less easily attacked by solvents, than platinum which has been long in use. Another most interesting fact which he established is, that platinum containing iridium is much more durable than platinum alone. He put into a still kept constantly at work, and so kept immersed in boiling sulphuric acid for two months, two capsules, one of pure platinum, and the other of platinum alloyed with iridium. At the end of the two months the capsule of pure platinum was found to be greatly deformed and its surface considerably corroded, and to have lost 19·66 per cent. of its weight, while the capsule of iridio-platinum retained its original form and brilliancy of surface quite unimpaired, and had lost only 8·88 per cent. of its weight. Since then, nearly all the platinum worked into alembics on the continent has been alloyed with a small portion of iridium.

Egyptian Bricks. By Professor UNGER.

From the Civil Engineer and Architect's Journal, September, 1866.

Prof. Unger, in a paper recently communicated to the Imperial Academy of Sciences, at Vienna, shows that Egyptian bricks possess a special interest, for they contain a variety of evidence preserved, as it seems, in an imperishable form. In his latest researches he has examined a brick from the pyramid of Dashour, which dates from between 3,400 and 3,300 B.C., and found imbedded among the Nile mud or slime,

chopped straw, and sand of which it is composed, remains of vegetable and animal forms, and of the manufacturing arts, entirely unchanged. So perfectly, indeed, have they been preserved in the compact substance of the brick, that he experienced but little or no difficulty in identifying them. By this discovery Prof. Unger makes us acquainted with wild and cultivated plants which were growing in the pyramid-building days; with fresh water shells, fishes, remains of insects, and so forth, and a swarm of organic bodies, which, for the most part, are represented without alteration in Egypt at the present time. Besides two sorts of grain—wheat and barley—he found the teff, the field pea, the common flax, the latter having, in all probability, been cultivated as an article of food, as well as for spinning. The weeds are of the familiar kinds: wild radish, corn chrysanthemum, wart-wort, nettle-leaved goosefoot, bearded hare's ear, and the common vetch. The relics of manufacturing art consist of fragments of burnt tiles, of pottery, and a small piece of twine spun of flax, and sheep's wool, significant of the advance which civilization had made more than five thousand years ago. The presence of the chopped straw confirms the account of brick-making as given in Exodus and by Herodotus; and the whole subject is so interesting that it is pleasing to know that Prof. Unger intends to follow it up. He is of opinion that, by careful examination of a large number of bricks, some light may be thrown on the origin of Egyptian civilization.

MISCELLANIES.

Protection of Wood against Insects.—The *Cosmos* mentions the report of a committee appointed to examine into the means of protecting carved wood against the ravages of insects, and of remedying the injury already done to ancient carvings. The committee report:

"1. That the worm may be destroyed by vapors, and especially by the vapor of benzine.

"2. The wood may be restored by saturating it with a strong solution of corrosive sublimate. To restore the color, which is injured by the mercury, ammonia is used, and then a light dose of hydrochloric acid. The wood is then to be injected with gum and gelatine to fill up the holes and strengthen the texture of the wood, and then varnished.

"But gilded work is very difficult to restore."

Would it not be well to prepare all carved wood beforehand by injecting, by Breant's process, a metallic solution, the nature of which might be altered according to the color desired? This process can be applied without injury to the most delicate carving, and would serve as an effectual preservative.

New Stuffing Box.—A correspondent of the *Cosmos* speaks in very glowing terms of the success of a new stuffing box, which appears to be coming into use on the French locomotives. He describes it as follows: The box is bored out in a conical form, and the cavity, in place

of hemp, is filled by a "cylindro-conic apparatus," through which the piston-rod passes. This piece is of anti-friction metal, and is cut in bevel in the direction of its length so as to form the parts which, when united, press outwards upon the conical surface of the box. The steam presses them forcibly against this, and at the same time forces the two parts into close contact by sliding over each other, so as to embrace the rod tightly. A spiral spring holds the plug in place when no steam pressure is on. It is said that these boxes have been in use for eighteen months without being unscrewed, and without allowing any escape of steam, and that the piston-rods are not in the least scratched or worn by it.

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Spectrum of Steam.—Professor Janssen reports to the Academy of Sciences, of Paris, an interesting experiment made to determine whether the dark rays of the solar spectrum, which have been shown to be due to the earth's atmosphere, and are, therefore, called the atmospheric or *telluric* bands, are due to the watery vapor. For this purpose an iron tube of 37 metres (39½ yards) long, packed in a box of sawdust to prevent radiation of heat, and closed at the ends by glass plates, was filled with steam of seven atmospheres pressure, and the light of sixteen gas-burners passed through it and formed a spectrum. By comparison with the solar spectrum it seemed that Fraunhofer's group A, the greater part at least of B, the group C, and the groups between C and D are due to the watery vapor. It was also seen, that while the transmitted light was dull in the most refrangible part of the spectrum it was bright in the red and orange; so that, although the steam absorbs energetically certain red and yellow rays, it is, on the whole, very transparent for the greater part of these rays, while it acts in a general way upon the most refrangible rays; consequently, the color of steam seen by transmitted light would be orange-red, and the redder the longer the column.

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Crystallization of Red Phosphorus.—M. Blondlot has succeeded in crystallizing red phosphorus which has hitherto been considered amorphous by sublimation in an atmosphere of nitrogen. He introduces about 2 grammes into a small mattrass, and then closes the neck hermetically by fusion, which can be done without igniting the phosphorus, provided the mattrass be held vertically. Allowing the apparatus to stand, it fills with white vapors, luminous in the dark, which are due to the oxidation of the phosphorus, and in twenty-four hours all the oxygen of the air is absorbed. The phosphorus may then be melted in a water-bath, while the upper part of the mattrass is protected from the heat. The phosphorus is deposited in transparent crystals of a cubical form, which, in a few days, form magnificent arborescences, and shine with the lustre and color of the diamond. This state may be preserved by avoiding the light, but by the sun-light, or even by diffused light, they pass to a brilliant garnet-red color and resemble rubies. A crop of colorless crystals may be got upon the surface of these.

Means of Reducing the Heat and Light of the Sun's Rays.—M. Foucault had made a great improvement in reflecting telescopes, by making the reflecting surface by depositing a thin coating of silver upon glass. This coating is so thin as to be transparent to a certain extent, with a beautiful blue color, and M. F. suggests the use of this film, deposited on the outer surface of the object-glass, as a substitute for colored glasses in the telescope. Experiment has shown that the effect is good, the definition being perfect, the color not inconvenient, and the eye relieved from all fatigue.

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New Arrangement of the Galvanic Constant Battery.—The greatest inconvenience about the constant battery is the difficulty of filling and emptying it, which occupies a great deal of time, and is very troublesome and annoying. M. Zaliwski-Mikorski has invented an arrangement by which this trouble can be in a great measure avoided.

The permanent part is a wooden trough, lined with a mastic composed essentially of sulphur, to which is added a small quantity of tar and lamp-black to prevent cracking. Into this are inserted alternately partitions of porous material and of gas-coke. When the liquid is poured into one of these sections, it is transmitted to all the corresponding ones, and to these only, by means of a gutter arranged in the lower part of the trough, and the apparatus works at once, the force of the current increasing as the trough is filled.

When it is desired to empty it, a little more liquid is added, which charges a syphon whose external branch is movable by means of caoutchouc tubes, and the interior branch projects from the gutter; so that it is not necessary to move the trough to empty it.

The plates of zinc which are movable rest upon projections at the base of the cokes; so that the weight of the metal itself establishes communication. One or more of the plates may be withdrawn without destroying the current, which is merely weakened correspondingly.

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Detection of Sulphuric Acid in Vinegar.—Böettger's *Polytechnisches Notizblatt* suggests a very simple, ingenious, and doubtless efficient method of detecting this very common and annoying falsification: Take about 50 cubic centimetres (1·7 fluid ounces) and boil it with a small quantity of starch until one-half the liquid has boiled away; after cooling add a drop of iodine. If sulphuric acid was present, the starch will have been converted into sugar, which will produce no color with iodine; but if no sulphuric acid be present, the starch will retain its properties, and give the characteristic blue color. Very little starch should be used in this test.

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Hardness of Silver.—Mathey, in Dingler's *Polytechnisches Journal*, points out that the hardness of silver, which sometimes interferes seriously with the chasing, and gives a mat and gray cut, and which is generally attributed to metallic impurities, is really caused by the high temperature at which the silver has been cast. When the crucible is suffered to cool until a light solid crust forms on the surface of the fused

metal, before casting, a soft silver, with a brilliant cut, is always obtained.

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Preservation of Milk.—Mr. Williamson states that the germs to which he attributes the fermentation of milk will bear boiling under atmospheric pressure unharmed; but that under a pressure of one and a half atmospheres they are destroyed, so that after such boiling, milk may be preserved indefinitely in air-tight cans.

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Pine Wool.—Attention is again called to the discovery of M. Pannewitz, of Breslau, by means of which a species of flannel is made from the fibres of pine leaves which is now exclusively used in the hospitals, prisons, and barracks of Breslau and Vienna for bed-coverings. The flannel thus made has the advantage of driving away all insects; it serves for stuffing as well as horse-hair, and costs but one-third of that article; it will make all kinds of garments which are of great durability and comfortable warmth. The liquid from the manufactory is now used as a medicine, and the refuse of the works makes the gas by which they are lighted.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 28, 1866.

The meeting was called to order, with the President, Wm. Sellers, Esq., in the chair.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were reported, including the following donations to the library: From the Chemical Society and the Society of Arts, London; the Adjutant General, the Smithsonian Institution, and F. Emmerick, Washington, D. C.; Prof. B. Howard Rand, A. R. Leeds, and T. D. Rand, Philadelphia; and the New Jersey Coal Company, South Amboy, New Jersey.

The various Standing Committees reported their minutes, together with a resolution of the Committee on Science and Arts, to whom was referred the question of a uniform system of danger signals.

Resolution passed by the Committee on Sciences and the Arts, at their meeting held May 23, 1866:

Resolved, That the Franklin Institute be requested to address a memorial to Congress, recommending the adoption of a uniform system of danger signals for all the railroads of the country.

This resolution, being regularly proposed and seconded, was adopted.

The various Special Committees reported progress.

The report of the Resident Secretary, on novelties in science and the mechanic arts, was then read, as follows:

Secretary's Report.

The Lenoir gas engine is now manufactured and supplied regularly in New York. Engines of from ½ to 4 horse power are furnished

at prices varying from $400 to $1300, and the specified powers are guaranteed by the Lenoir Gas Engine Company, No. 435 East Tenth Street, New York. As this motor is no novelty to the scientific world, and has been often described already, we will only notice, in this place, a few points, by way of suggestion.

It is claimed that this engine does not act so much by reason of an explosion as by the mere heating of air in the cylinder, accomplished by burning the fuel (gas) in its midst.

These engines are largely used in Paris, and elsewhere, for pumping water, light printing, turning sewing machines, hoisting goods, lifting passengers and baggage at hotels, propelling street cars, raising stone and other building materials,—for which last purpose more than 80 gas engines are now used in Paris alone. The cleanliness, mobility, convenience, and safety of this instrument commends it to the use of those requiring a motor of moderate power for intermittent work. The point in which improvement seems to be most desirable is in the means employed for igniting the gas The Ruhmkorff coil is now used for that purpose, but is open to some objection on account of its battery, &c. The excellent apparatus invented by Mr. Cornelius would undoubtedly subserve the required purpose, if electricity is essential, or the improvement of M. Pierre Hugon, noticed in our last report, where small gas jets do the work of the electric spark, might be adopted.

An improved bar vice, invented by Colonel P. G. Chorman. In this instrument the outer jaw is fixed, and is firmly united with the bed-plate, on which travels the inner and movable jaw. This last is drawn up by a long screw which passes through the outer or fixed jaw, as is usual in common vices, and works in a thread cut in the inner jaw. The advantages claimed are simplicity of construction and strength to resist concussion. This vice is, in fact, essentially an anvil, and will bear as much hammering as would an anvil of the same material. The effect of a blow upon the jaws, or work held between them, is transmitted to the bed-plate without bringing any strain upon the screw.

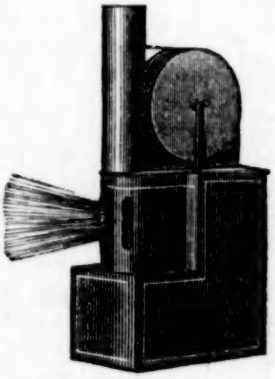
A safety-valve in connexion with kitchen range water-backs, by T. S. Speakman, Esq. This consists of a very compact safety-valve kept shut by a spiral spring, whose tension can be readily adjusted by means of a screw-cap, which can readily be attached to a water-back in such a manner that when the pressure reaches a dangerous point, it will give vent to the steam, so avoiding an explosion, which we know from experience may be of a very serious character.

A side-wheel propeller, by Mr. T. S. Speakman. This consists of a circular blade with a double inflection or returned spiral curve, which, being partially immersed and rotated, produces an action much like that of an oar when used for sculling. Experiments are now in progress, and a more full account will be given at a subsequent time.

The method of working the Atlantic Telegraph with an open circuit, by which all disturbing effects from earth currents were avoided, was fully explained by the aid of diagrams projected on the screen.

The improved signal system of A. F. Ward was exhibited in like manner.

The new magnesium lamp, improved and manufactured by the American Magnesium Company, of Boston, was then exhibited. This instrument is represented in the accompanying cut. The clock-work, by which the motion is produced, is enclosed in the square-shaped portion below, and at the back. In the rounded front, are the parts for feeding the ribbons, &c. These consist of two little rollers, between which the ribbon is passed, and regularly delivered by their motion. They are placed immediately over the front opening, at which the ribbon is ignited and burned. Below this opening work eccentric cutters, which nip off the ash thread from time to time. The ribbon is supplied from flat bobbins, represented at the top, from which it passes into the chimney and to the rollers. The whole structure is exceedingly compact, so as to fit easily a common magic lantern box. The most important novelty in this instrument is the arrangement of the chimney and draft. This is entirely closed below, with the exception of the opening shown directly in front of the flame. By this means *the draft blows directly into the face of the light,* thus sweeping off the smoke, and making the intensest light exactly where it ought to be. The efficiency of this arrangement is very easily proved by opening the door at the rear for removing the ashes, when the light will fall off to about half its former brightness. The practical performance of this instrument, as you now see, is of the most satisfactory character. (The lamp was lit, placed in a lantern, and used for about 20 minutes in the exhibition of various photographic views, without the least variation in light or need of adjustment, and was finally extinguished only because no further experiment with it was desired. The quality of the light was most excellent, comparing favorably with that of the best oxyhydrogen arrangement, and the steadiness of the flame all that could be desired for lantern exhibitions.)



An account of this improved lamp was sent, about three weeks since, to the editor of the *British Journal of Photography*, who, in his paper, No. 340, page 534, thus expresses his opinion: "On receiving Dr. Henry Morton's letter, in which the improvement was described, we lost no time in obtaining and testing a chimney similar to that described by him, and the result has proved most satisfactory.

"Mr. Solomon, who was present during the trial, and with whose lamp the experiment was performed, unhesitatingly expressed his opinion that, in consequence of this improvement, a light of equal intensity might be obtained from one ribbon of the metal as was formerly obtained from two. This, of course, expresses at once a saving of one-half, by the adoption of the new chimney. But, in addition to this, there are collateral advantages, such as increased steadiness, &c."

The absorption and dialytic separation of gases by colloid septa, by Thomas Graham. We find, in the Proceedings of the Royal Society, some very remarkable statements on the above subject, by the distinguished chemist designated.

It appears that a thin film of india rubber, though impervious to air while in its usual gaseous form, is capable of first liquefying the constituent gases of the atmosphere (O and N) in its pores, of then transfusing these liquids through its substance, (as it would chloroform or ether,) and, lastly, of allowing these liquids to evaporate again, or rather expand, into a gaseous form on the other side, if a vacuum be there produced.

The two gases named suffer these changes however, with unequal facility, oxygen passing two and a half times more rapidly than nitrogen. In other words, while all the oxygen contained in the air gets through, only half the nitrogen passes.

The gas passed through contains, therefore, 41·6 per cent. of oxygen, while air has but 21 per cent.

This dialysed air will rekindle wood burning without flame, and may be obtained by the use of a silk bag varnished with rubber or pure rubber balloon. The first prevented from collapse by layers of felted carpeting, and the last by a stuffing of sawdust, a vacuum being produced inside, in either case, by the use of an air-pump or Sprengel's air-exhauster. (See *Jour. Frank. Inst.*, Vol. LI., page 369.)

Palladium condenses gases in a wonderful manner similar to the above, as the same author remarks. Thus foil from the hammered metal condenses six hundred and forty-three times its volume of hydrogen at a temperature below 100° C. Platinum takes up 3·8 vols. Palladium will not however, absorb oxygen or nitrogen. Fusion, strange to say, reduces the capacity of both metals.

This property explains, in some degree, the wonderful porosity of platinum and iron tubes when heated, to hydrogen gas, lately noticed by MM. Deville and Troost.

A new process for the extraction of sugar, by Mr. Roberts, is described in *Engineering*, page 337, and is stated to have been applied with excellent success at Selowitz, in Austria, in making beet sugar. The saccharine plant is cut in slices, which are steeped in water, when the sugar passes out from their tissue by an action of osmose, leaving the colloid impurities, such as albumen, behind. The usual means are employed to make the extraction as thorough as possible with the least amount of water.

The absorption bands produced in the spectrum by vapor of water have been elaborately studied by Janssen, as we see from the *Comptes Rendus* of August 13. An iron tube, 120 feet in length, was used, filled with steam at 7 atmospheres pressure. Strong groups of lines were observed corresponding with D and A of the solar spectrum; beside a multitude of others, these lines especially abound in the blue part of the spectrum. Similar general conclusions to those obtained as above were published some time since by J. P. Cook. (See *Silliman's Journal*, Vol. XLI., page 178.)

Diffused sunlight is red, or has an excess of red light, according to Memorski, of Vienna, as we should anticipate from the absorptive action of vapor on the blue rays noted above.

The spectrum of comet of 1866, by William Huggins, Professor of the Royal Society.

On January 9, the spectrum of the comet was observed. The telescope and spectrum apparatus which were employed were those described in the article previously published, "On the Spectra of Some of the Nebulæ." The appearance of the comet was that of an oval, nebulus mass, surrounding a very minute and not very bright nucleus. The length of the slit of the apparatus was greater than the diameter of the telescopic image of the comet, and the appearance presented when the centre was placed in the middle of the slit, was that of a broad continuous spectrum fading gradually at both edges. Nearly in the middle of this spectrum, and about midway between *b* and *c* of the solar spectrum, a bright point was seen. The absence of breadth in this bright point, in a direction at right angles to that of dispersion, showed that this monochromatic light was emitted from an object of no sensible magnitude in the telescope, that it came, in fact, from the minute nucleus. This shows that the light of the coma differs from that of the minute nucleus. The nucleus is self-luminous, and is composed of ignited gas. The continuous spectrum of the light of the coma indicates that it shines by reflected solar light. We know from observation that the comæ and tails of comets are formed from matter contained in the nucleus. The usual formation of the tail appears to be, that as the comet approaches the sun, material is thrown off at intervals from the nucleus in the direction towards the sun. This material is not at once driven into the tail, but usually forms, in front of the nucleus, a dense luminous cloud, into which the bright matter of the nucleus continues to stream. In this way a succession of envelopes may be found, the material of which afterwards is dissipated in a direction opposite to the sun, and forms the tail. Between these envelopes dark spaces are usually seen. The light of the comet was feeble, and the continuous spectrum made it difficult to detect lines. A cylindrical lens was used; but only the bright line already described was seen. In the paper "On the Spectra of the Nebulæ," it was shown that this bright line corresponded with the brightest lines of nitrogen, and this may indicate that cometary matter consists principally of nitrogen or of some elementary substance existing in nitrogen.

"Further observations on the spectra of some of the nebulæ with a mode of determining the **brightness of these bodies"** from the same authority as above.

The results already presented are confirmed by new observations, namely, that clusters and nebulæ give either a continuous spectrum or a spectrum consisting of one, two, or three bright lines. The positions of these lines are the same as those of the bright lines of the nebulæ before described. Some of these spectra appear irregularly bright in some parts of the spectrum. Analysis by the prism shows that some of the nebulæ consist of luminous gas, existing in masses,

which are properly continuous, and the nebulæ in the telescope present not points but surfaces, in some cases subtending a considerable angle.

By means of a special apparatus, the light of three nebulæ was compared with the light emitted by a sperm candle burning at the rate of 158 grains per hour. The results are—

The intensity of nebula, No. 46,281, H 4 = $\frac{1}{1501}$ part of that of the candle.
" " annular nebula in Lyra. = $\frac{1}{2033}$ " "
" " dumb-bell nebula = $\frac{1}{19604}$ " "

The estimation in each case refers to the brightest part of the nebula. The amounts are too small by the unknown corrections needed for the loss which the light has sustained in its passage through space, and through the earth's atmosphere. These values have an importance in connexion with the gaseous nature of the source of the light, which the spectroscope indicates. Similar estimates, made at considerable intervals of time, might show whether the brightness of these bodies is undergoing increase, diminution, or a periodic variation.

The viscosity or internal friction of air and other gases, by J. C. Maxwell, Proceedings of the Royal Society. All bodies are capable of having their form indefinitely altered, and those which resist the change of form with a force depending on the rate of deformation may be called viscous bodies.

Various experiments have been made on the viscosity of elastic solids and gases by others, but the author has investigated the laws of viscosity in air by causing three disks, interposed between four other fixed disks, to turn about a vertical axis by means of a steel suspension wire. During the oscillations of the movable disks, the viscosity of the air in the six strata caused a diminution of the amplitude of oscillation which was measured by means of the reflection of a scale in a mirror. The apparatus was in an air-tight case. The observed diminution in the arc of oscillation was partly owing to the viscosity of the suspension wire, but this was eliminated by a series of experiments. The conclusions drawn from the experiments agree, as far as they go, with those of Mr. Graham, "On Transpiration of Gases." They are as follows:

1. The co-efficient of viscosity is independent of the density, the temperature being constant.

2. The co-efficient of viscosity increases with the temperature.

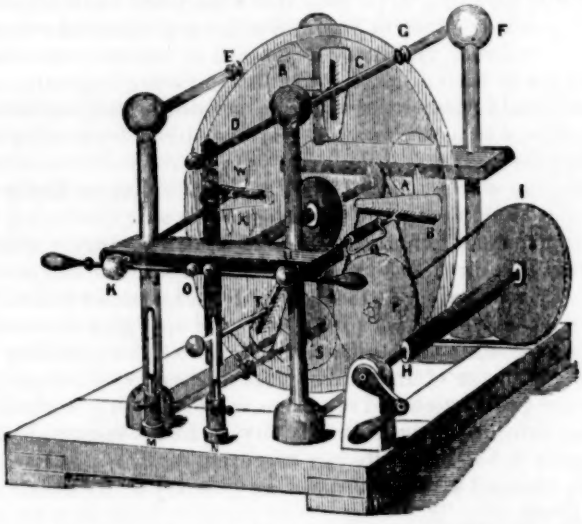
3. The co-efficient of viscosity of hydrogen is much less than that of air.

4. The ratio for carbonic acid was found to be 859. Graham makes it 807. Graham's calculation is supposed to be the most correct.

5. Experiments on dry air were tried to ascertain whether any slipping takes place between the glass and the air in contact with it. If such action took place its amount was unappreciable.

Some new facts with regard to the Holtz machine were then stated by the Secretary as the result of his own observations. The machine exhibited and described on a previous occasion was found to operate in a very satisfactory manner for some days, but suddenly, without any evident cause, failed entirely, (though the weather was very dry and cold,)

to yield anything more than the most insignificant and feeble sparks. This failure led to a long course of experiments, the result of which has been to show that for efficient working the strips of paper attached to the fixed disk should be very slightly insulated on their surfaces, but as thoroughly as possible upon their edges. The cause of failure being the electric penetration of the insulation at the rear edge of the paper, a few words as to the theory of the machine in this connexion will make this matter plain. As was shown in a previous report, (see this *Journal*, Vol. LII., page 282,) the card points A S X R are constantly feeding the respective strips B T W C, to which they are attached, with electricity. If these papers were perfectly insulated on their surfaces and edges they would act like so many Leyden jars, the paper answering to the inner coating, the insulating material to the glass, and the constant current of air moving between the plates playing the part of



an outer coating connected with the ground, by constantly removing one kind of electricity and supplying the other. The charge in the paper would then continue to accumulate without any limit other than the resistance of the insulating material, which must soon yield, and a spark penetrating this, all capacity for retaining a charge is at once lost, as in a ruptured Leyden jar, and the electricity supplied by the paper point at once leaks out through the perforation, and, descending upon the revolving plate, neutralizes the opposite sort of electricity there presently developed, and so prevents the charging of the paper point and strip next in order, thus interrupting the action of the machine.

If, however, the surface of the paper is not well insulated, a diffused leakage takes place all over it, which does not cause the whole charge to be lost, but acts as an overflow after a certain tension has been reached. This leakage, beside, occurs directly opposite the brass combs, and causes a corresponding increase in the amount of opposite electri-

city which these are delivering upon the revolving plate. If this leakage occurred upon the edge of the paper, it would be out of range with the combs, and would not thus tend to compensate the mischief it does.

The tension of the fluids is, of course, greatest at the edge of the papers; these should therefore be well insulated to prevent all 'concentrated leakage.' This may be best done by shellac varnish applied in a narrow line on the edge, any broad band of insulation tending to develop the sort of action described above. We consider the facts here stated of importance, because without a knowledge of them, this otherwise most efficient machine becomes almost worthless, being liable to fail at any moment. Such was the condition of the machine now exhibited when received from its manufacturer, Ruhmkorff. It was merely a question of time and use, as to how soon it would give out and become useless, and clearly nothing was known by its manufacturer or inventor as to a means of repairing it, (if even this weak point was recognised,) for no hint is given of either in very voluminous publications on the subject of this machine. If, however, we give an excess to the insulation of the papers at their edge, the liability to failure is greatly reduced, and if this should occur by cracking of varnish or mechanical wear, a coat of shellac, which may be applied and rendered dry in a few minutes, will correct the evil.

The machine now exhibited was, an hour since, perfectly useless, owing to the cracking of some varnish used as an experiment, but was restored in about 20 minutes to its present satisfactory condition.

Attention was directed to the fact, not mentioned in the previous report, that, by connecting the two horizontal brass combs and balls, leaving the upper and lower ones insulated, and charging the machine as usual, sparks could be taken from the upper ball on D exactly as from the prime conductor of an ordinary machine, and all the usual apparatus illustrating attraction and repulsion, most efficiently worked. A battery of Leyden jars charged in this way, in half a minute, by 30 turns of the handle H, had one of its jars ruptured, though it had been before repeatedly charged with 500 turns of an ordinary 30-inch plate machine without injury.

The essential principle of agaric, prepared by Thomas J. Brown, of Philadelphia, was exhibited. It was obtained as follows: The natural fungus was treated with hot alcohol; the solution so obtained was then further treated with sub-acetate of lead and litharge and filtered, then acted upon by sulphuretted hydrogen, again filtered and twice evaporated and redissolved. The substance so obtained crystallized in minute translucent needles, almost colorless, but yielding a faint yellow tint when in mass.

The solution in pure alcohol did not fluoress, nor did an addition of water and sulphuric acid develop in it this action. An alcoholic solution of quinine also gave no fluorescence even when diluted with water, but acquired this property on the addition of a few drops of sulphuric acid.

Phosphorus may be crystallized by sublimation in an atmosphere of nitrogen, as M. Blondlot has shown, and then forms minute white cubes, which acquire a ruby color on exposure to light.

Mineral springs, like those of Saratoga, have been discovered near Harrisburg, Pennsylvania.

A lime light has been placed on a tower in the centre of Hyde Park, and is to be used for general illumination.

A bed of peat, fifteen inches thick, and covering 1500 acres, has been discovered near Des Moines, Iowa.

A vein of fine slate was recently discovered in Fluvanna county, Virginia. It is said to equal the celebrated Buckingham slate, which took the premium at the World's Fair.

Lead in great abundance has been discovered in the valley of the Green River, in Kentucky. A mine will be opened at once. Similar discoveries are reported in Owen and Shelby counties.

The San Antonia Herald says, the accounts of rich deposits of gold in the vicinity of Los Pinos Altos, in southern New Mexico, are confirmed. The proceedings on the Gila have been very successful.

A house having nine stories above the ground-floor, and with basement and cellars eleven stories, is in course of construction at Paris, in the Quartier de Roule. The lodgers on the upper stories will be raised on a platform ascending noiselessly every minute, and raised by hydraulic power.

In France a steam carriage for towing boats and barges in rivers and on canals has been invented. It was tried a few days since on the river Oise, and was found to answer perfectly. Running on the towing-paths it makes ascents and descents and turns as easily as horses do.

The Secretary then called attention to some printed rules for prompt treatment in case of accidents, such as might occur to those employed about machinery, and requested Dr. Packard, by whom the rules were prepared, to make further examinations. Dr. Packard then remarked as follows:

"When accidents take place on railroads, or in factories or machine shops, as they will in spite of every care, it not unfrequently happens that the persons injured suffer greatly, or even lose their lives, because no one present knows exactly what ought to be done at once, before a surgeon can be had. In the course of the last sixteen years, I have seen repeated instances of this kind; and one which came under my notice last summer so impressed me, that I determined to try to do something for the mitigation of the evil.

"I have therefore prepared a set of rules, as to the course to be pursued in such injuries as cause shock or collapse, or loss of blood, and as to the mode of carrying an injured person comfortably. These I propose to furnish on a card or sheet, 14½ inches by 21, at the cost of paper and printing. They have been tested by submitting them to the scrutiny of railroad men, and brought down to the greatest simplicity. Nearly 4000 of these have been distributed, and are now in use on different railroads. It is not proposed to post them before the public, but in the private offices, tool-houses, baggage-cars, etc., so that they may strike the eye of the employés who are to be guided by them.

"The similar papers headed 'Injury by Machinery' are intended for

use in factories and machine shops. Here, however, a much smaller number would be required for each establishment, and cards might be conveniently used instead of papers. I should be glad to supply either set of rules, at such a cost as will cover my own expenses, to any one desiring them." These cards can be obtained by addressing the author, at 1415 Spruce Street.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

Memoirs of the National Academy of Sciences. Quarto. Washington: Government Printing Office, 1866.

The National Academy of Sciences was chartered by the government of the United States for the purpose of advising the government in matters depending on the application of science, and making such experimental researches as should be needed for government uses. In addition to a considerable number of important investigations and reports made by its committees, we have in the volume now before us the first instalment of their memoirs, and it must be admitted that, although few in number, they are of a very high character of merit, and rank the Academy creditably with its European sisters.

The first memoir is *the Reduction of the Observations of Fixed Stars, made by Le Paute D'Agelet*, in 1783–85, by B. A. Gould. This embodies the result of a very laborious investigation, by means of which a very large catalogue of star observations, which were not heretofore available for astronomers' use, in consequence of the undetermined errors, have been revised and corrected, and made available. It is quite curious to see how, after an interval of some eighty years, the errors of graduation and defects of form of the instrument used, can be ascertained and determined, and the results eliminated from the observations so as to make them comparable with more modern labor. Astronomers only can appreciate the immense benefit of Prof. Gould's labors; but any person of ordinary mind and education can appreciate the ingenuity and acuteness necessary to develop such results.

This, which is the longest of the memoirs, and extends to 261 pages, is followed by an investigation by Prof. Peirce, *On the Theory of the Saturnian System*, in which was discussed the conditions of equilibrium of the rings of the planet, and their dependence on the satellites demonstrated. If any one wants to whet his mental appetite by a taste of the modern mathematics, we recommend these twenty-four pages to his particular attention. This is followed by a short memoir of but four pages by the late Augustus A. Gould, M. D., "*On the Distribution of certain Diseases in Reference of Hygienic Choice of Location for the Cure of Invalid Soldiers.*" This paper will be found more generally readable than abstract mathematics. It presents an interesting table of the statistics of consumption, and shows the importance of attending to vital statistics more generally and closely than has hitherto been done.

Professor Norton, of Yale College, gives us at length his theory of shooting stars, and it may possibly console some of the unfortunates who lost a night's sleep in looking for the predicted shower, to learn here the grounds on which the prediction was made, and what the prediction really was—which will be found to differ somewhat from the newspaper accounts. Finally, the volume closes with an elaborate memoir by Prof. Bartlett, of West Point, "*On Rifled Guns*," the strains to which they are subjected, the materials from which, and the dimensions of which, they ought to be made. If we are not mistaken, this will prove to be a classical treatise upon this subject, and one to be referred to by all interested in ordnance hereafter.

In conclusion, we congratulate the Academy on the amount of thoroughly good work here set forth, and hope that they will not, as they grow older, weary of well-doing.

Peat and its uses as Fertilizer and Fuel. By SAMUEL W. JOHNSON. Professor of Analytical and Agricultural Chemistry, Yale College. Fully illustrated. 18mo., pp. 168. New York: Orange, Judd & Co.

In this little work, Professor Johnson has given us a very full and valuable account of a material which is forcing itself into notice in consequence of the high price of coal and other fuel. In this treatise he explains, first, the origin of peat, its chemical composition and physical and chemical properties. He then explains and discusses its uses as a manure, its effect on various soils and under different climates, and its mode of preparation for such purposes. Afterwards he goes very fully into the subject of the use of peat for fuel, and describes, with drawings, the various machines which are used for its preparation. He also treats of its use as a means of obtaining illuminating gas. The high reputation of Professor Johnson is sufficient guarantee that the work thus laid out has been ably and conscientiously done, and we recommend this little book to our readers as very valuable, not only as a special treatise upon its subject matter, but as a model for other treatises upon similar subjects.

Warming and Ventilating the Capitol.

It appears that the House of Representatives called upon the Secretary of the Interior for a report from the architect, upon the warming and ventilation of the Capitol. Mr. Walter had already availed himself of the assistance of Professor Henry and Dr. Charles M. Wetherill to institute a series of experiments upon the result of the system, and the result is the present report by Dr. Wetherill upon the subject. His conclusions, that the amount of ventilation compares favorably with the best of similar attempts in Europe, that the air is introduced in sufficient quantity without inconvenient drafts, and at a proper temperature, but is deficient in hygrometric moisture, are interesting more or less to all of us. But what will or ought to interest us more, is the great mass of information upon the general subject, which appears to be for the most part unknown, misconceived, or neglected among us. In this respect the labors of Dr. Wetherill are invaluable, and some Sanitary Commission, Board of Health, or other official body ought to see to republishing this report in a large edition and disseminating it widely among our citizens

A Comparison of some of the Meteorological Phenomena of OCTOBER, 1866, *with those of* OCTOBER, 1865, *and of the same month for* SIXTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	October, 1866.	October, 1865.	October, for 16 years.
Thermometer—Highest—degree, .	75·00°	78·00°	90·00°
" date, .	2d. & 8th.	10th.	4th, '58.
Warmest day—mean,	67·00	73·17	78·30
" " date,	2d. & 22d.	10th.	6th, '61.
Lowest—degree, .	37·00	37·00	28·00
" date, .	5th.	25th.	25th, '56.
Coldest day—mean,	45·33	44·83	35·80
" " date, .	5th.	25th.	27th, '59.
Mean daily oscillation,	13·55	11·23	15·17
" " range, .	5·60	5·13	5·42
Means at 7 A. M., .	52·47	52·55	51·35
" 2 P. M., .	62·34	60·15	62·81
" 9 P. M., .	55·47	54·85	55·32
" for the month,	56·76	55·85	56·49
Barometer—Highest—inches, .	30·326 ins.	30·225 ins.	30·452 ins.
" date, . .	6th.	30th.	25th, '61.
Greatest mean daily press.	30·302	30·209	30·378
" " date, .	5th.	30th.	25th, '61.
Lowest—inches, . .	29·425	29·155	29·012
" date, . .	30th.	15th.	26th, '57.
Least mean daily press.,	29·506	29·226	29·059
" " date, .	30th.	19th.	26th, '57.
Mean daily range, .	0·147	0·171	0·144
Means at 7 A. M., .	29·931	29·778	29·907
" 2 P. M., .	29·870	29·746	29·865
" 9 P. M., .	29·911	29·786	29·893
" for the month, .	29·904	29·770	29·888
Force of Vapor—Greatest—inches,	0·611 in.	0·527 in.	0·731 in.
" date, .	2d.	11th.	7th, '61.
Least—inches, .	·112	·094	·065
" date, .	25th.	28th.	21st, '59.
Means at 7 A. M., .	·326	·293	·315
" 2 P. M., .	·322	·281	·339
" 9 P. M., .	·345	·298	·325
" for the month,	·331	·291	·326
Relative Humidity—Greatest—per ct.,	96·0 per ct.	94·0 per ct.	97·0 per ct.
" date,	13th.	18th.	often.
Least—per ct.,	31·0	34·0	23·0
" date, .	5, 15, & 25,	29th.	21st, '59.
Means at 7 A. M.,	78·7	70·5	77·7
" 2 P. M.,	54·5	51·7	50·0
" 9 P. M.,	74·1	66·5	72·9
" for the month	69·0	62·9	68·9
Clouds—Number of clear days,* .	11	11	9·8
" cloudy days, .	20	20	21·2
Means of sky cov'd at 7 A. M.,	61·6 per ct.	51·0 per ct.	56·6 per ct.
" " " 2 P. M.,	56·1	57·1	55·7
" " " 9 P. M.,	42·6	38·1	40·0
" " for the month	53·4	48 7	50·8
Rain—Amount, ...	3·538 ins.	3·358 ins.	2·928 ins.
No. of days on which rain fell, .	8	6	8·8
Prevailing Winds—Times in 1000,	N54°41′ w ·168	N77°35′w ·293	N73°18′ w·237

* Sky one-third or less covered at the hours of observation.

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